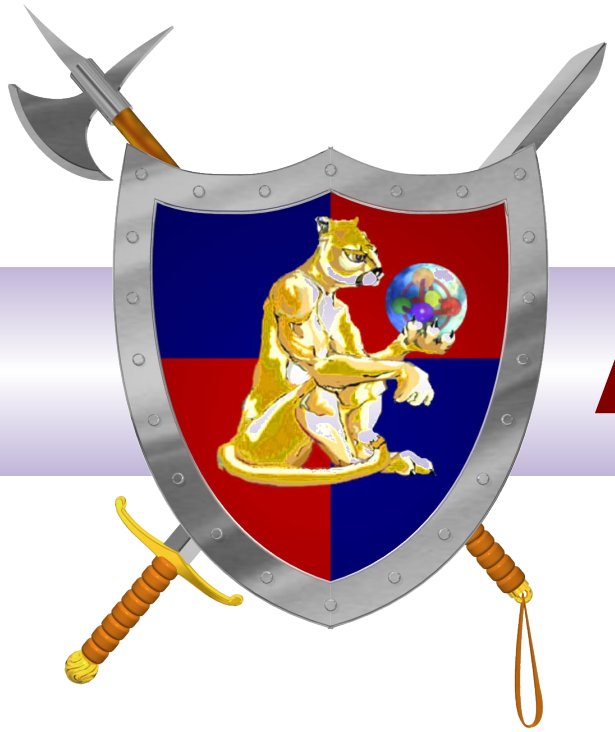

ALP and UltraLog

Overview Briefing

May 2002

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DARPA / Joint Logistics Technology Office (JLTO)

Logistics Superiority

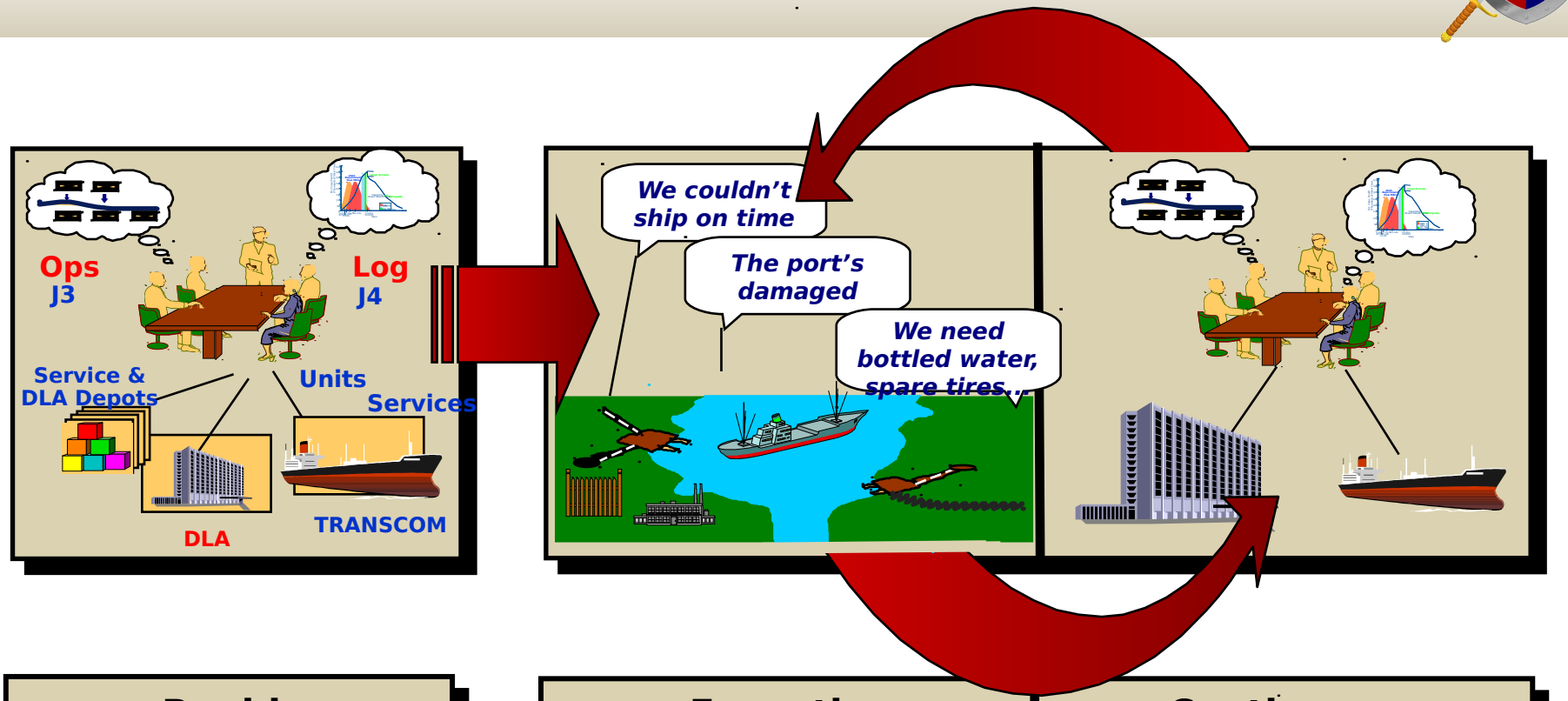
Advanced Logistics Project (FY96—FY01)

- **End-to-End Control of the Logistics Pipeline**
  - **Fastest ever construction of a level-5 logistics plan (~hour [agents] vs. weeks [humans])**
  - **World's most advanced agent architecture**

UltraLog Program (FY01—FY04)

- **Hardened and Survivable Logistics**
  - **Robust, Secure, and Scalable logistics agents**
  - **Hardened to withstand simultaneous cyber and kinetic attack**

Future Logistics Vision



Rapid Planning

- *All Echelons*
- *Executable detail*

Execution Monitoring

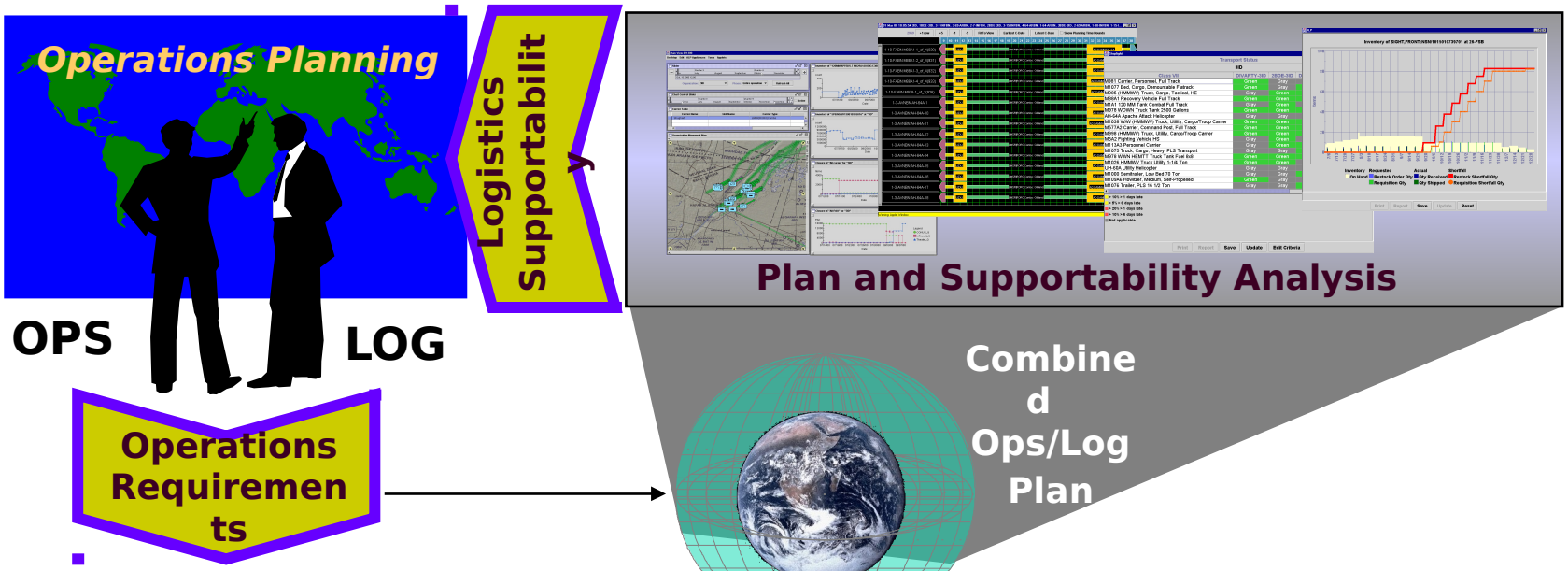
- *Manage flow*
- *Deploy plan sentinels*

Continuous Replanning

- *Redirected flow*
- *Localized Replanning*

Continuous Dynamic Planning, Monitoring and Replanning

An Approach to Integrated Global Logistics



Advanced Logistics Project "Grand Challenges"

Automated Log Plan Generation

- Automate plan development
- Level 5, execution detail
- Build in under 1 hour
- Strong J3/J4 Partnership

End-to-End Movement Control

- Minimize staging
- Globally optimize lift
- Item level planning

Execution Monitoring

- Continuously monitor during execution
- Automatically detect deviations
- Selectively correct plan in

Rapid Supply & Sustainment

- Continuous bottom-up demand generation
- Sourcing virtual DoD/Com inventories

Advanced Logistics Project (ALP)

ive: Getting Control of the Logistics Pipeline...

- Operating at All Echelons, All Phases of Operations
  - Continuously Planning, Managing, and Providing Visibility
    - Linking all Elements into a Living, Distributed, Global Logistics P

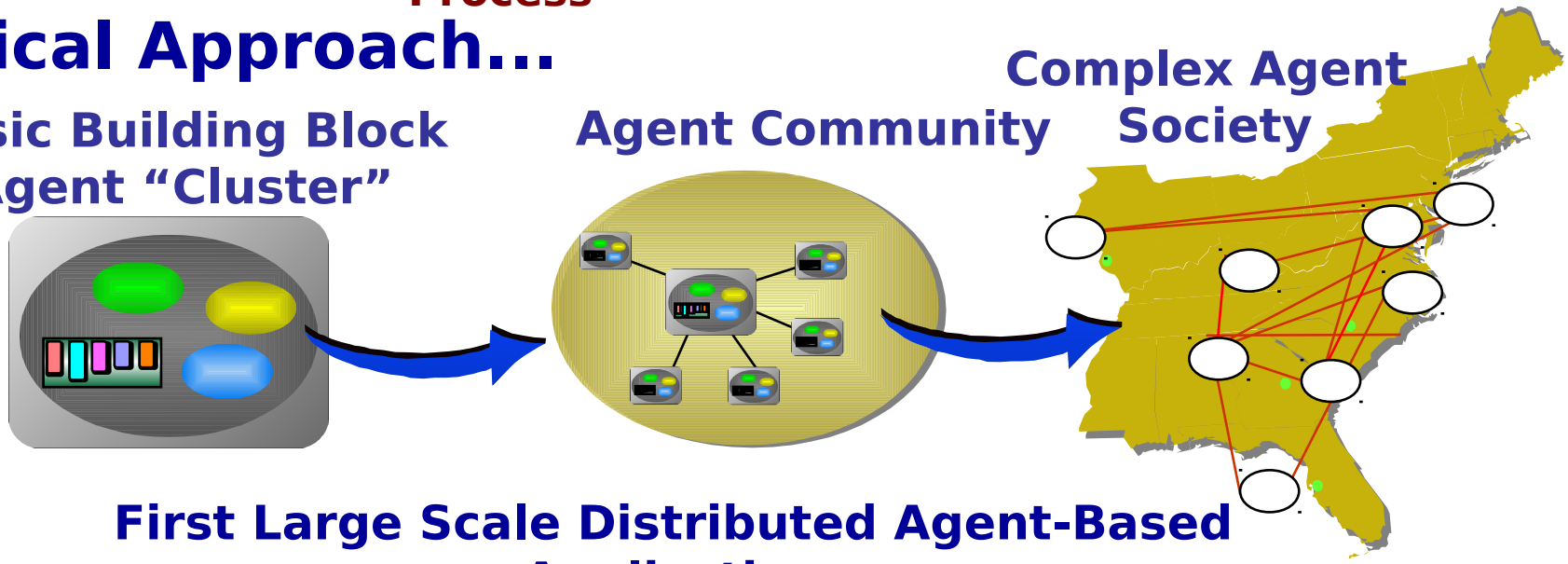
In-Storage | In-Process | In-Transit | In-Theater

echnical Approach...

Basic Building Block Agent "Cluster"

Agent Community

Complex Agent Society

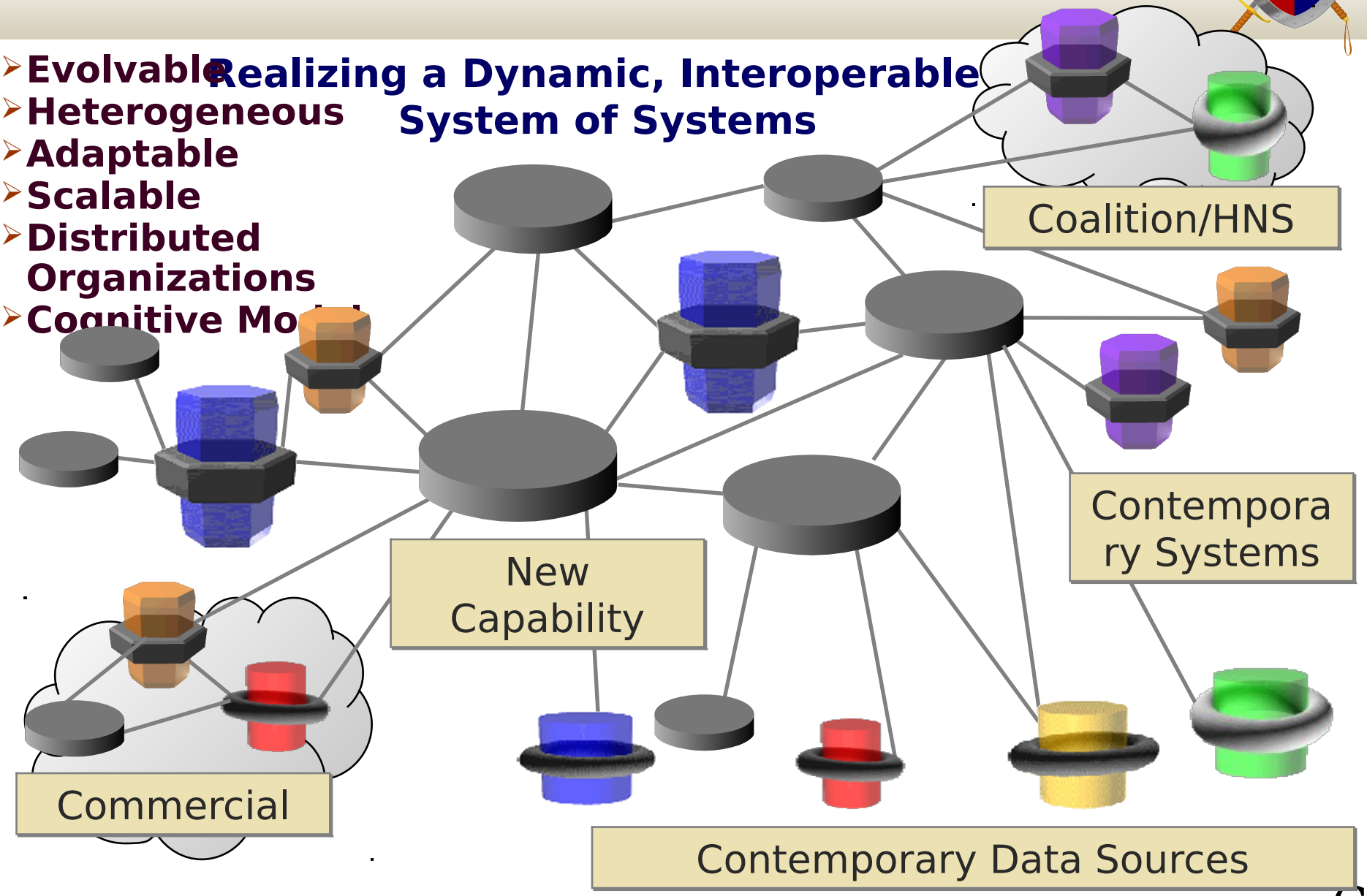


First Large Scale Distributed Agent-Based Application

Target Capability

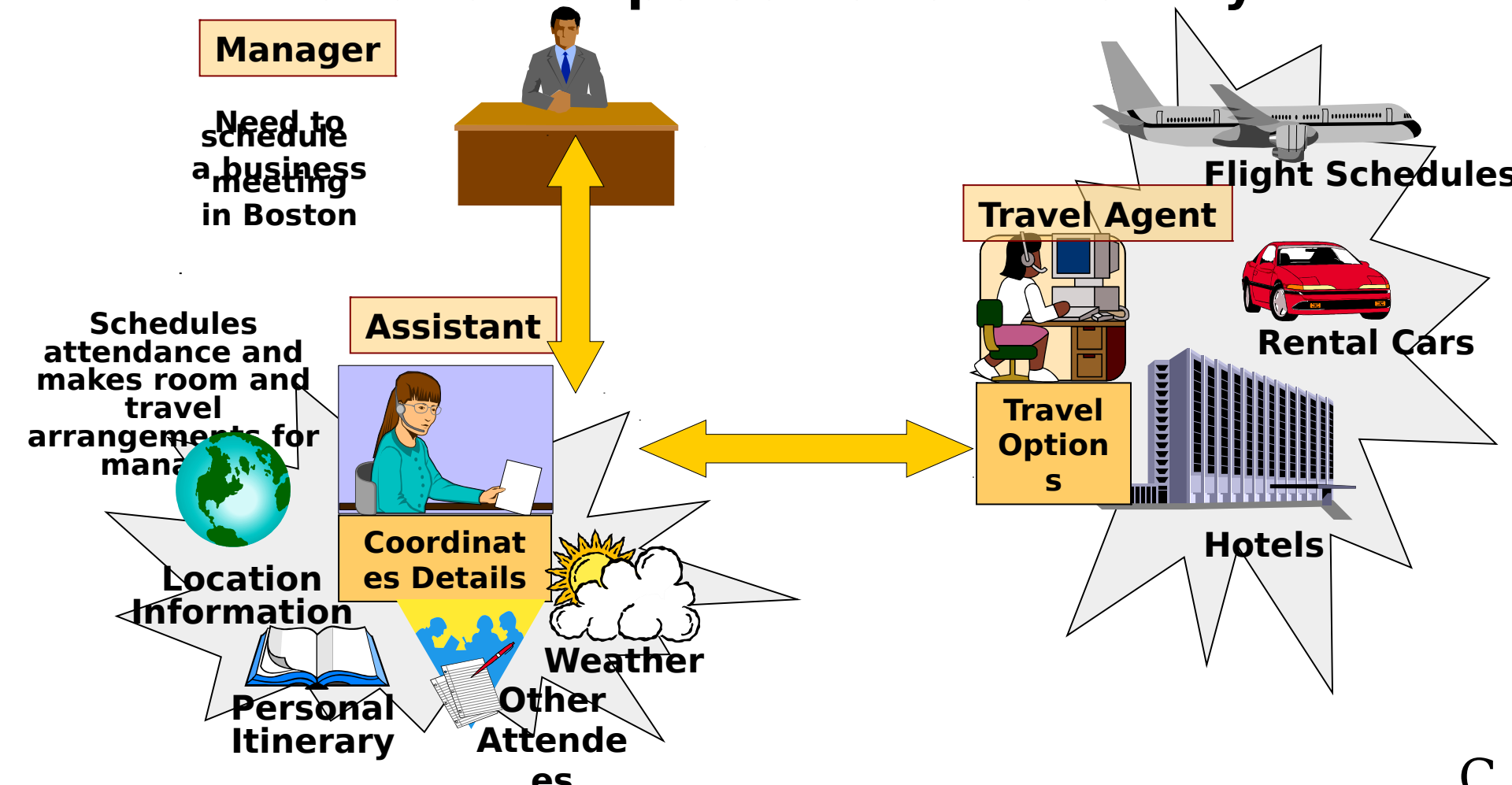
- Evolvable
- Heterogeneous
- Adaptable
- Scalable
- Distributed Organizations
- Cognitive Mo

Realizing a Dynamic, Interoperable System of Systems



Concept of an Agent

An independent person or entity that can autonomously accomplish tasks for another person or other entity



What is a Software Agent?

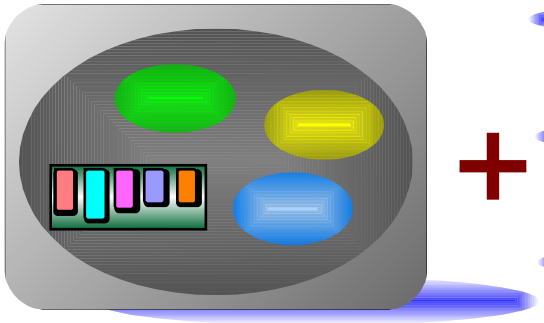
- **Agents are software pieces that autonomously accomplish tasks on behalf of another entity**
- **Agents are a style of computer program**
  - **They execute as machine code just like all other programs**
  - **They are not magic; just because you program in the agent style doesn't mean you have solved very hard AI problems**

Typical Properties of Software Agents

- **Goal Oriented and Taskable**
- **Adaptive**
- **Proactive**
- **Autonomous**
- **Extensible**
- **Collaborative**
- **Mobile**

Creating an ALP Agent

Generic Agent + **Business Rules & Processes** = **Domain Specific Agent**



+

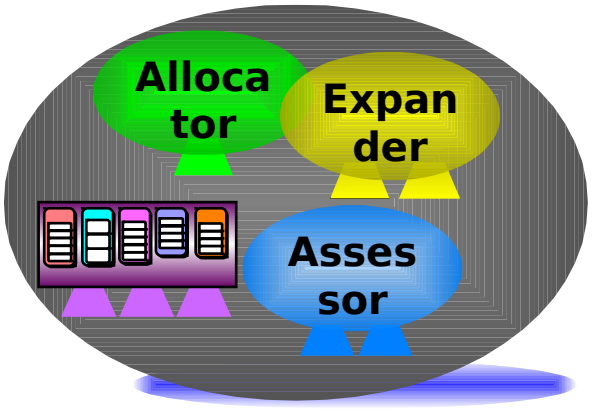
Mission Planning

Mission Assignment

Weather Status

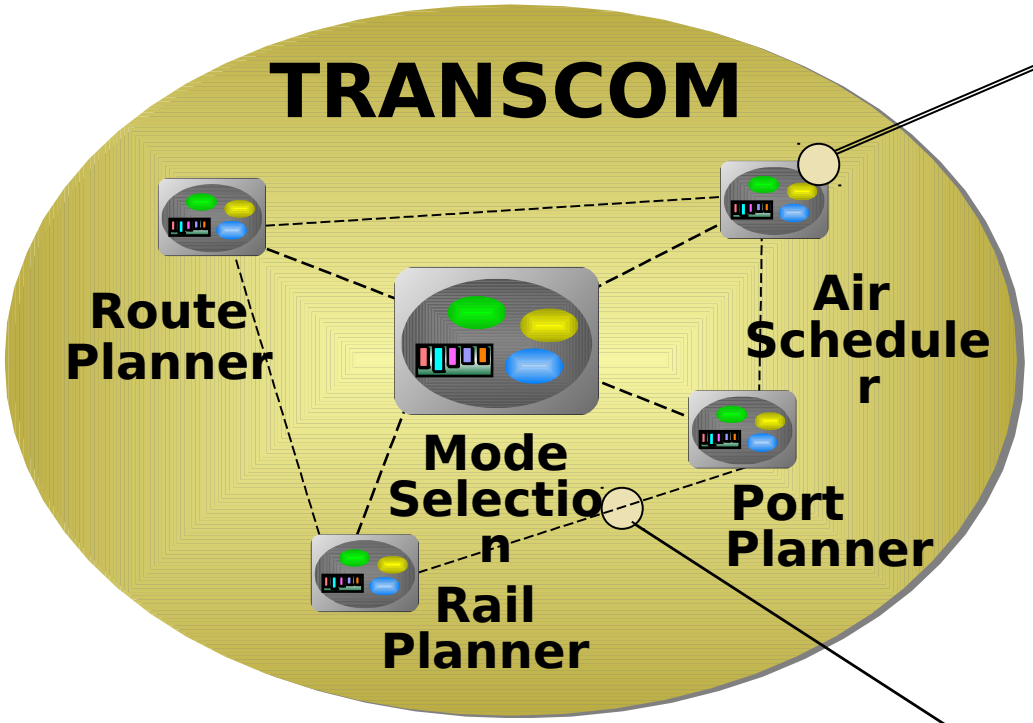
A/C Availability

=



Agent Architecture + *Air Scheduling Behaviors* = *Air Scheduling Agent*

Building Communities

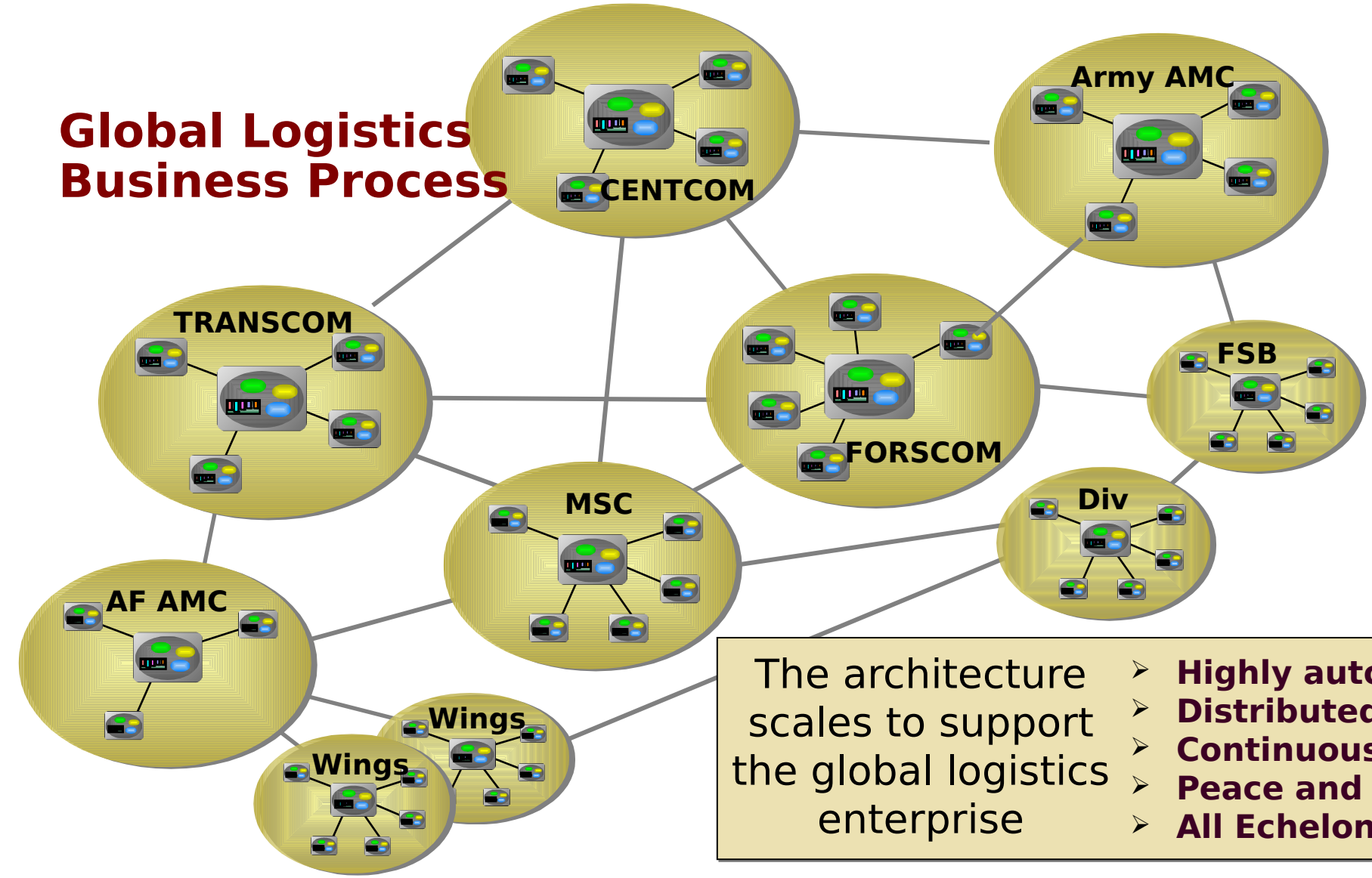


Each agent a specialist at part of the organizational process

Agents collaborate to develop integrated organizational plans

Organization-Level Logistics Business Processes

Building Societies

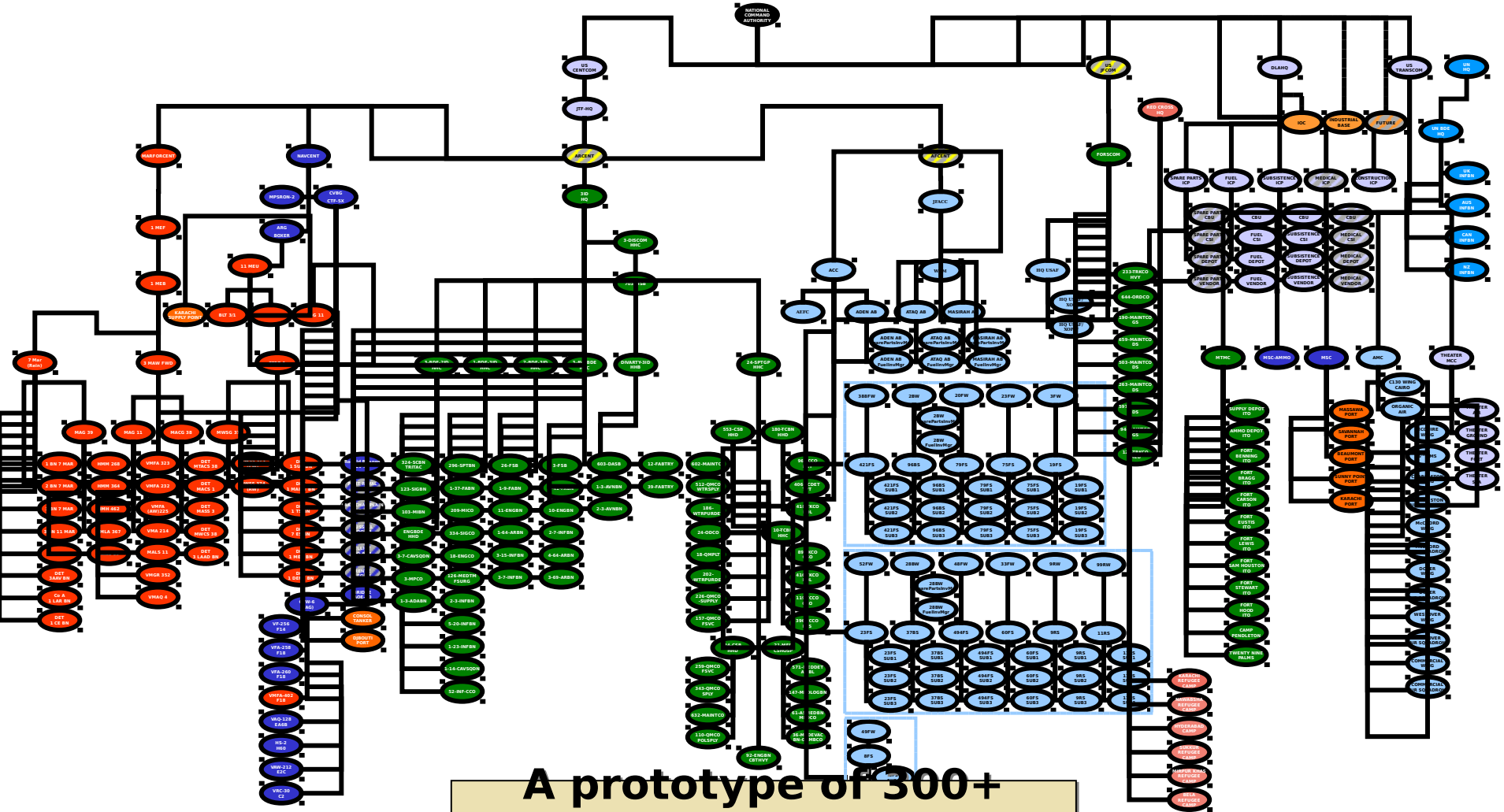


The architecture scales to support the global logistics enterprise

- Highly automat
- Distributed
- Continuous
- Peace and War
- All Echelons

C

The ALP Prototype Society



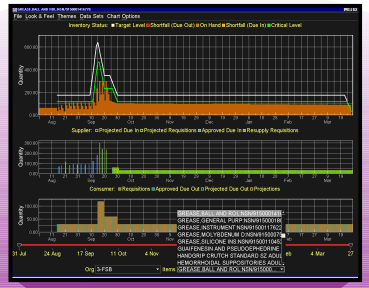
A prototype of 300+ organizations, each with one or more agents.

ALP Final Functional Demonstration May 2001

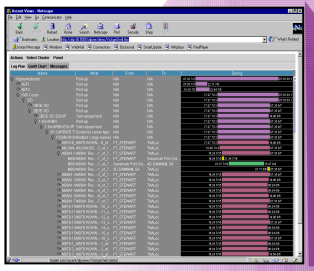
Hypothetical 2005 Force Deployment Plan

Slices of the Plan

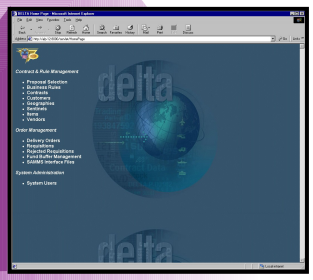
Inventory Management



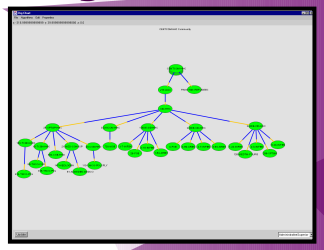
Log Plan



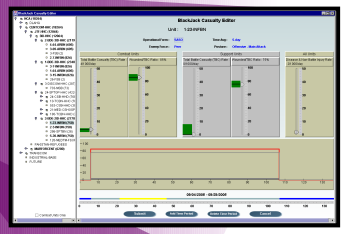
Sourcing



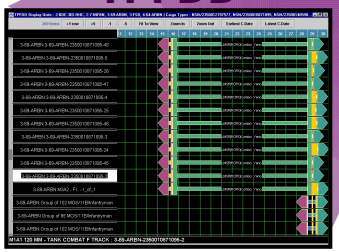
Organization



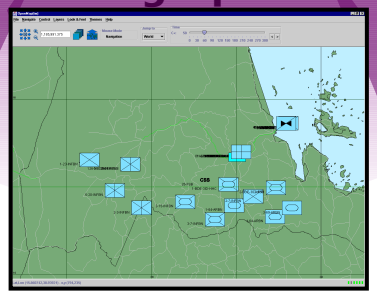
Medical



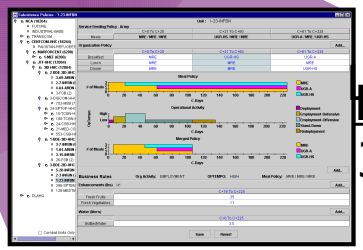
TPFDD



Geographic



Subsistence



Elements of The Plan

300 orgs, 33,000 people, 20,000 MEIs

4 services, DLA, TRANSCOM HNS, NGOs, Coalition Forces

Transportation Fort to In-Theater Dest classes I, III, IV, V, VIII, IX

Time-Phased demand/sourcing

DS/GS Maint, Material Handling

ISB Transshipment

3-echelon Medical care

Multiple concurrent operations

Elements of The Demo

Execution Monitoring

Dynamic Replanning

and much more

ive Business Rule Changes

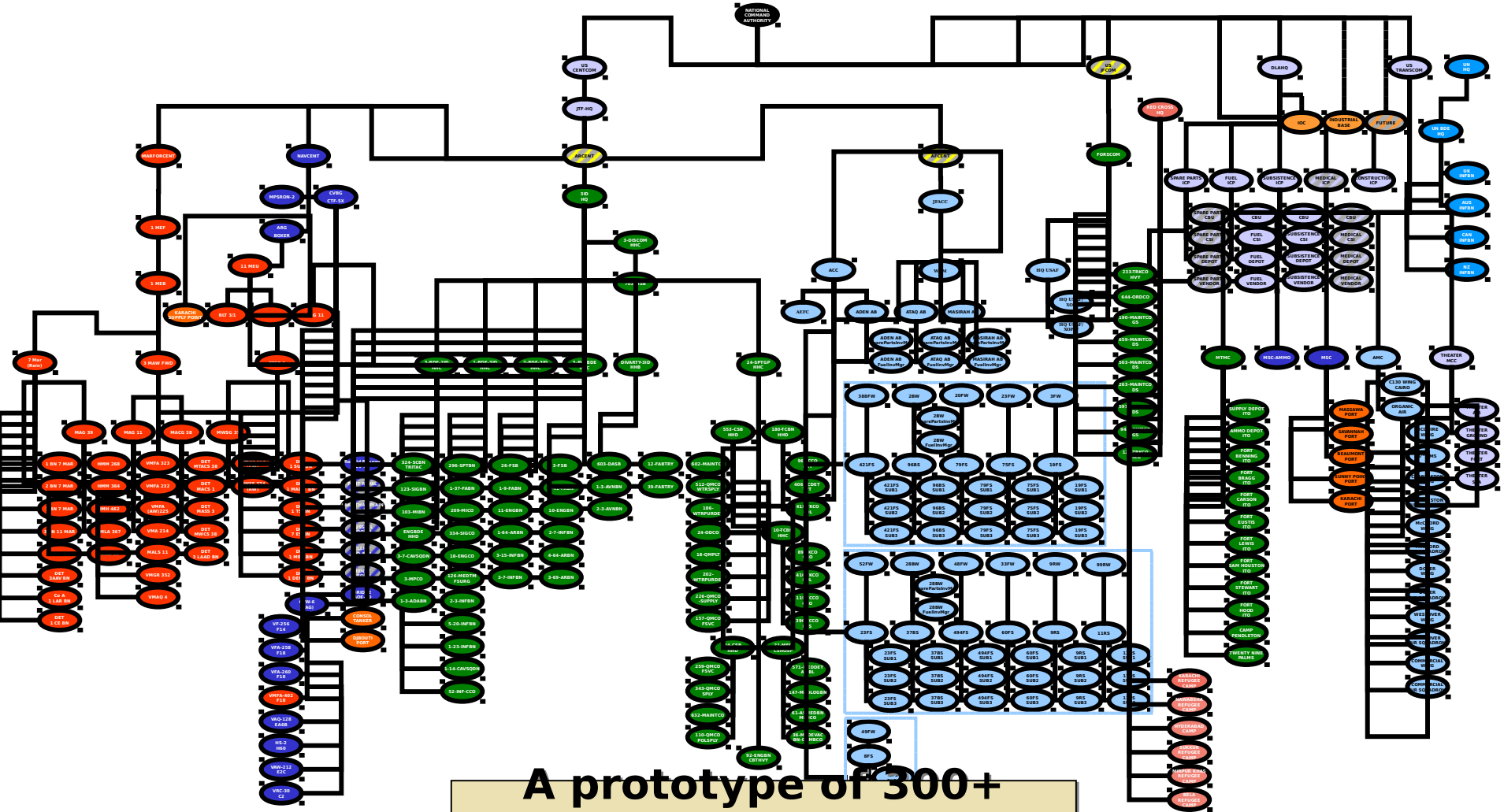
Elements of The Society

300+ agents, 30 machines

Standard NT/Linux machines

C

The ALP Prototype Society



A prototype of 300+ organizations, each with one or more agents.

Development of the Log Plan

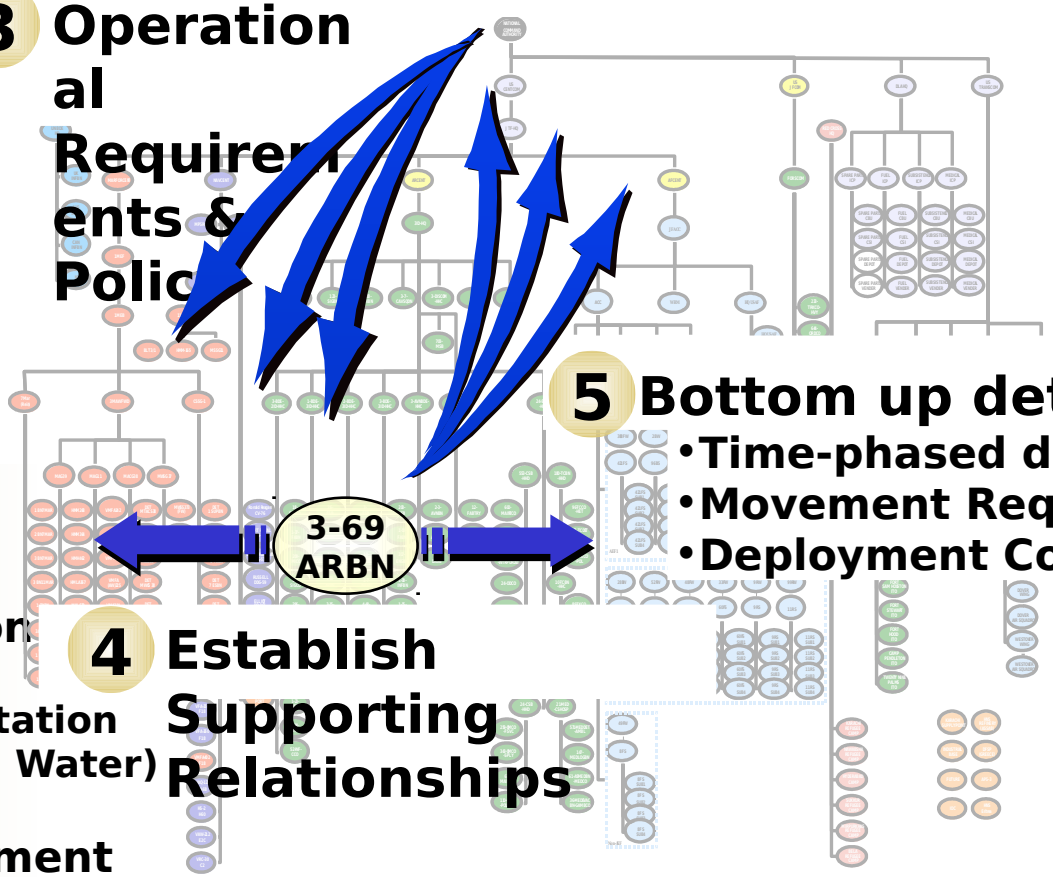
2 Course of Action Passed @ t=0

Time Phased Mission Requirements

- Mission Activity
- Location Requirements (RDD, EAD, etc.)

Log Plan Develop t

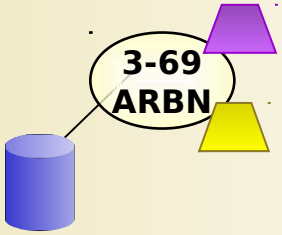
3 Operation al Requirem ents & Polic



5 Bottom up detai

- Time-phased dem
- Movement Requir
- Deployment Cons

1 Data & PlugIns



Demand Generation

- Supply
- Strategic Transportation
- Subsistence (Food, Water)
- Major End Items

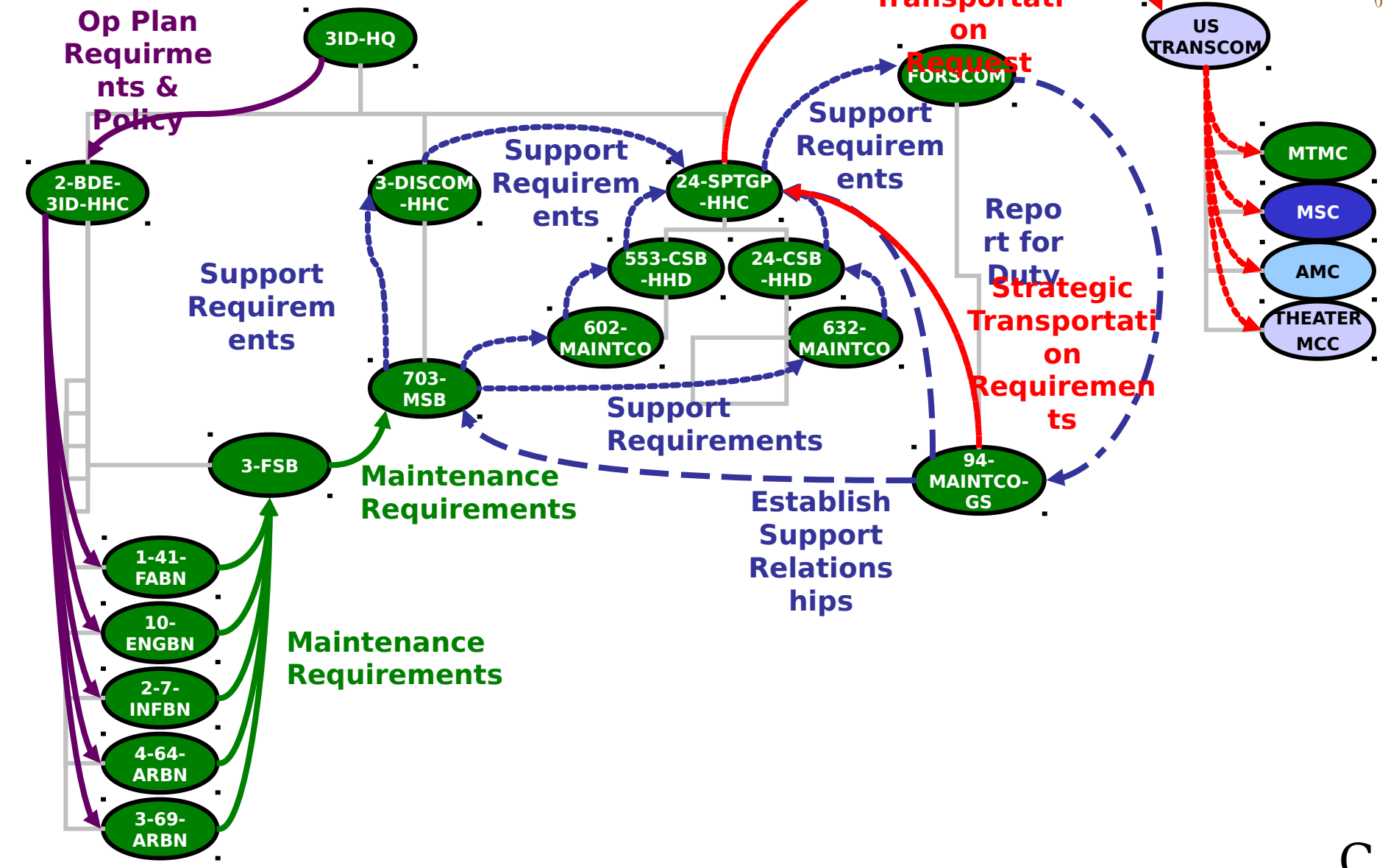
Inventory Management

JTAV, TCAIM S II

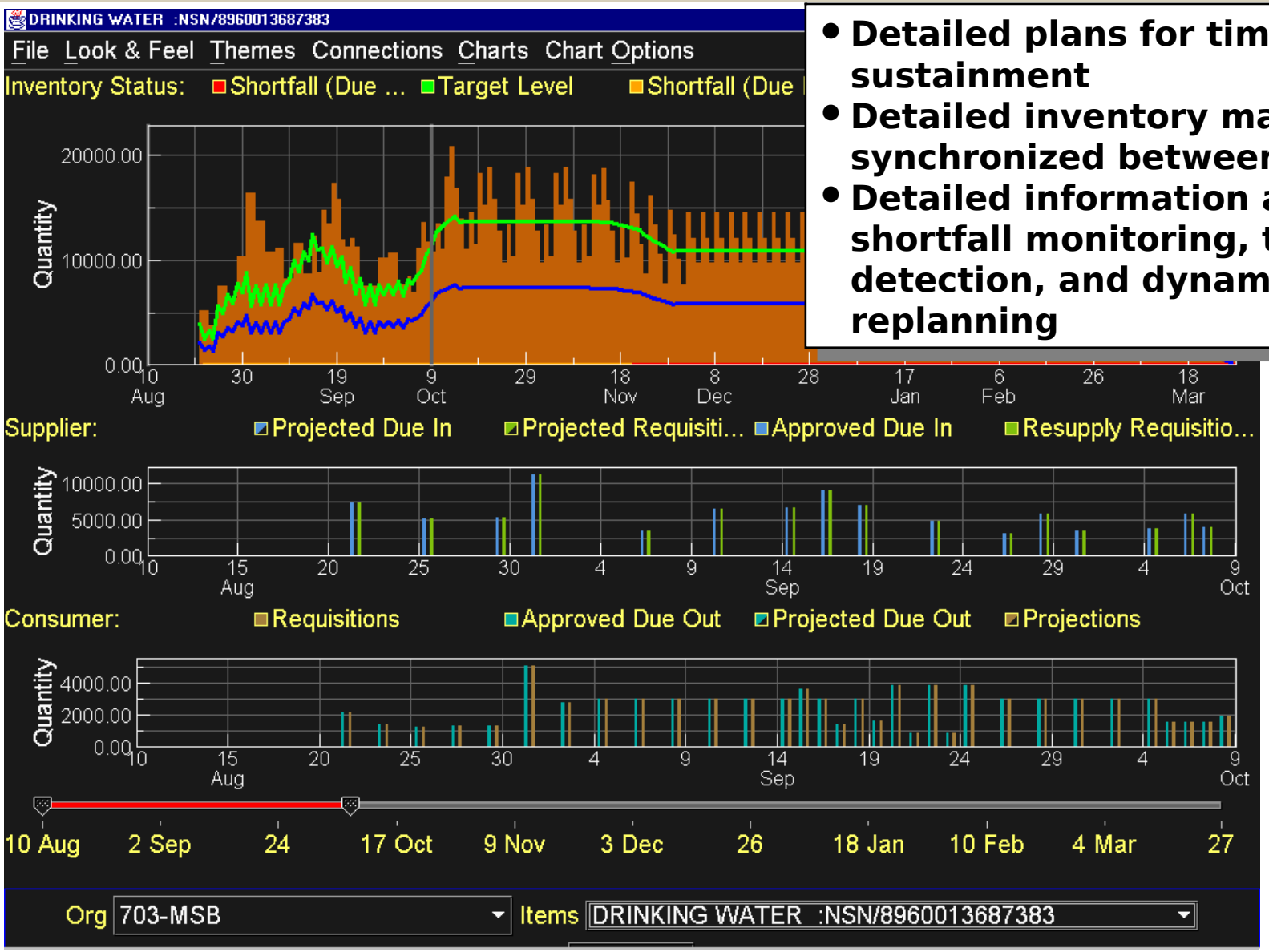
4 Establish Supporting Relationships

C

Example Thread: Maintenance

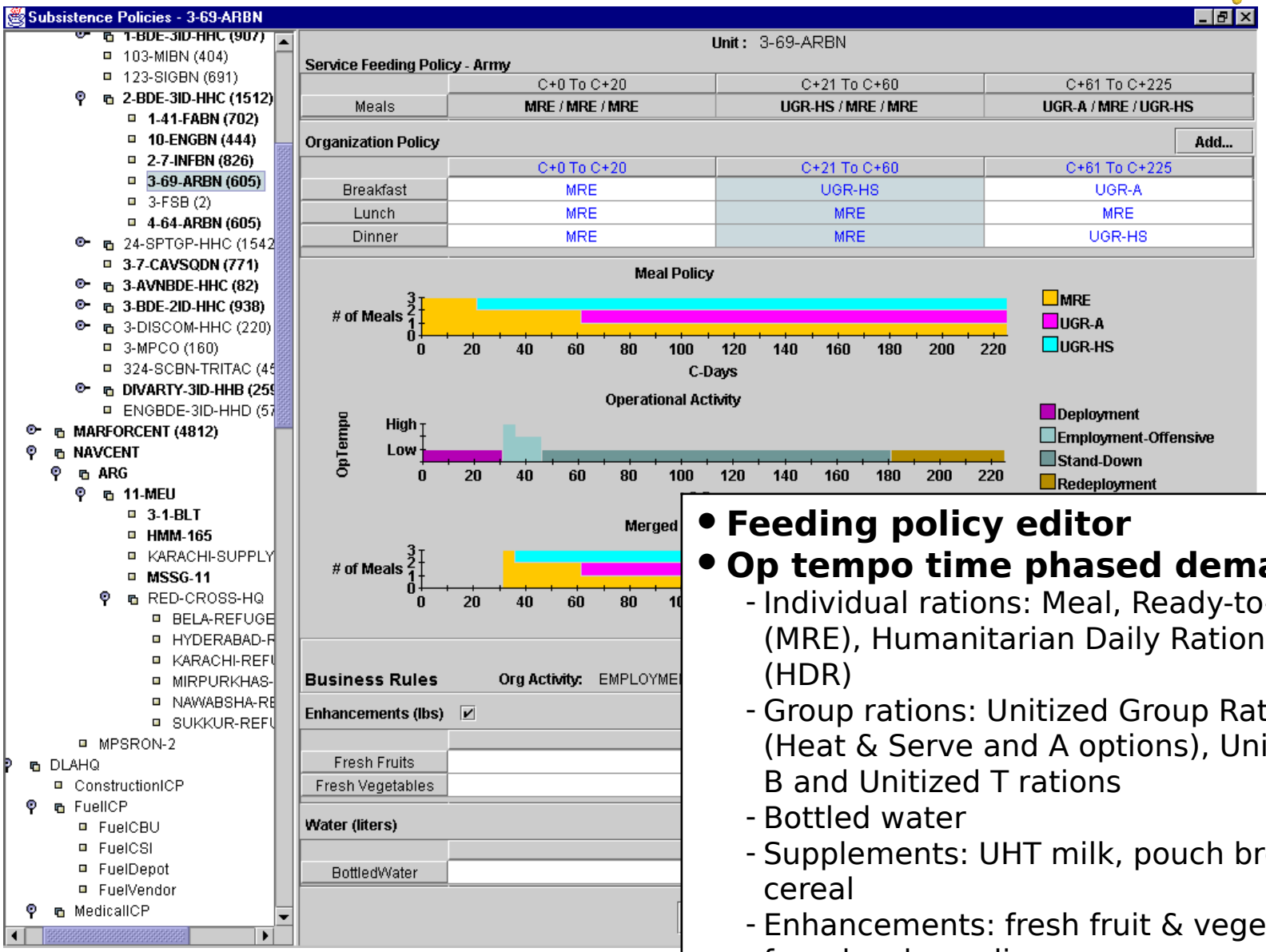


Logistics Plan View
Detail Inventory View



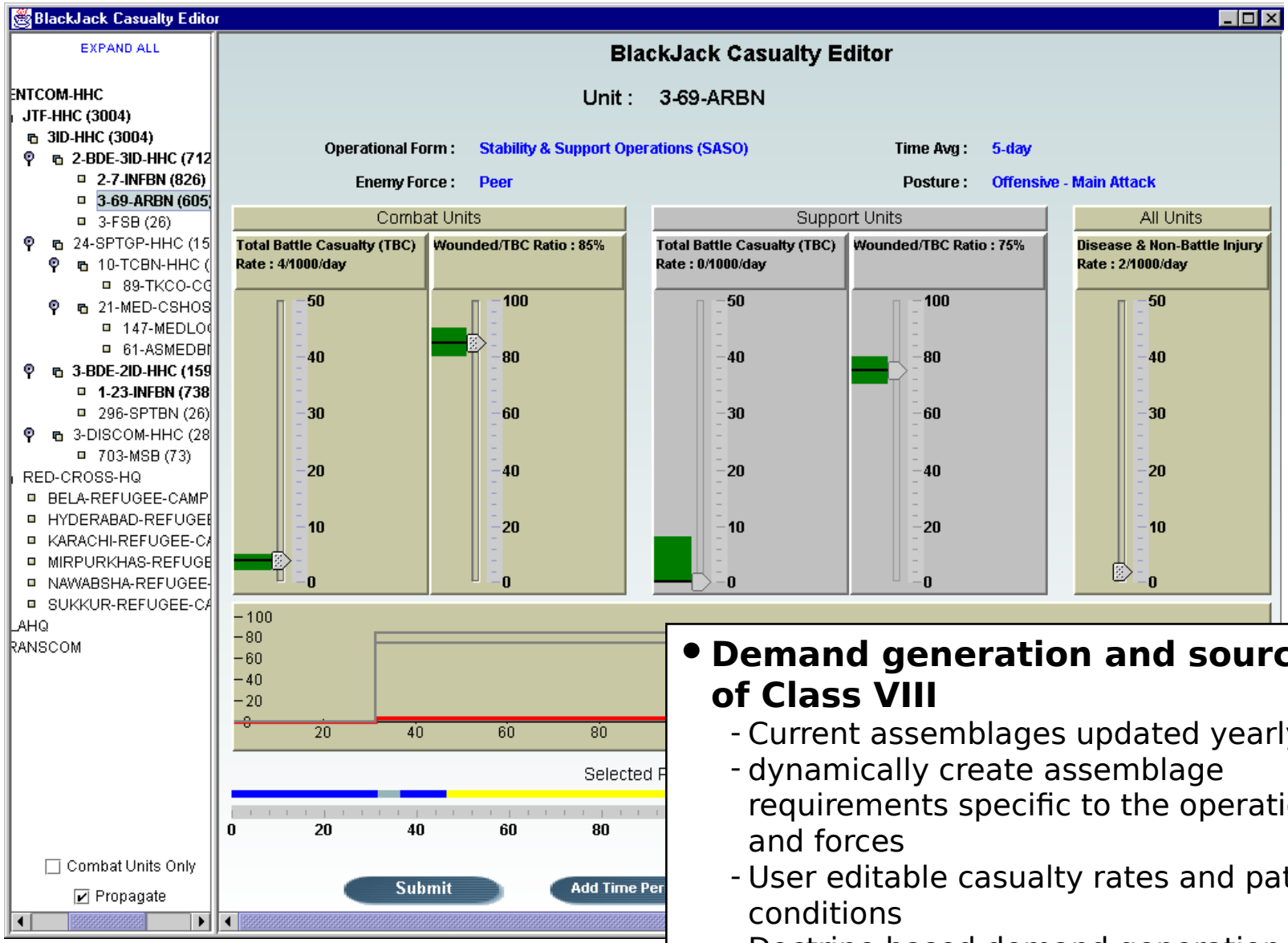
- **Detailed plans for time-phased sustainment**
- **Detailed inventory management synchronized between echelons**
- **Detailed information allows shortfall monitoring, trend detection, and dynamic replanning**

Class I Demand Generation



- **Feeding policy editor**
- **Op tempo time phased demand**
  - Individual rations: Meal, Ready-to-Eat (MRE), Humanitarian Daily Rations (HDR)
  - Group rations: Unitized Group Rations (Heat & Serve and A options), Unitized B and Unitized T rations
  - Bottled water
  - Supplements: UHT milk, pouch bread, cereal
  - Enhancements: fresh fruit & vegetables

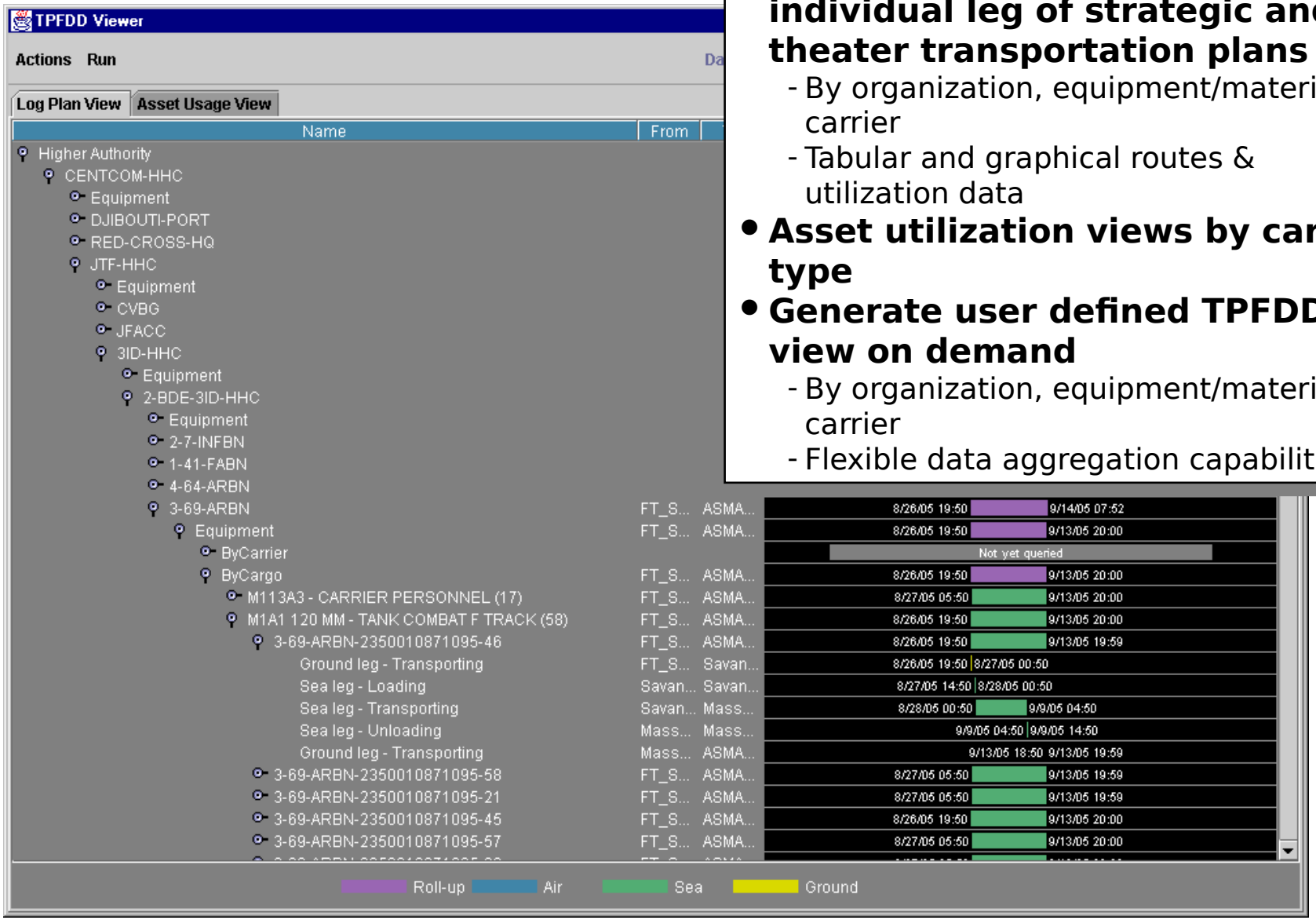
Health/Medical Services: Class VIII Casualty Editor



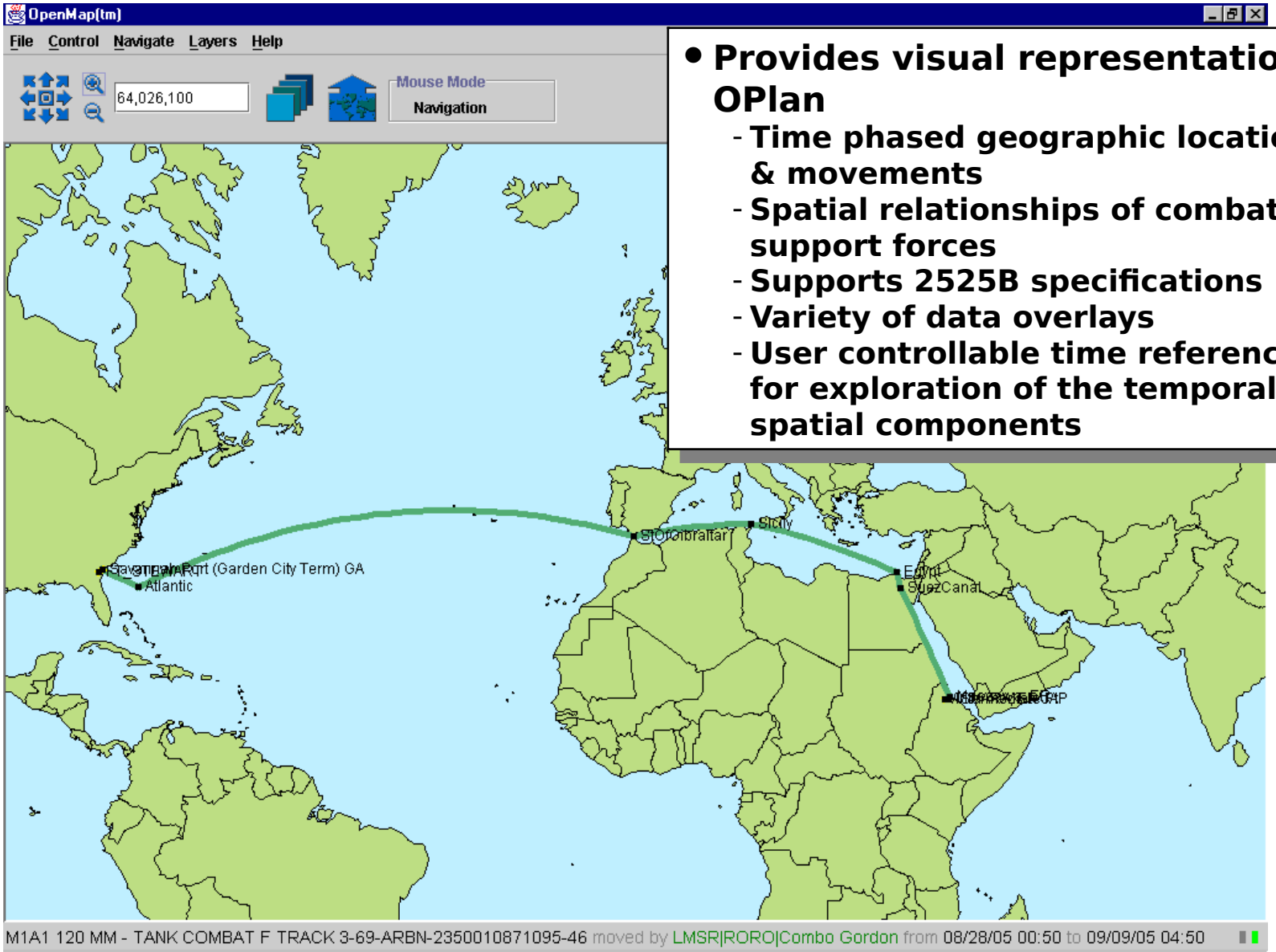
- **Demand generation and sourcing of Class VIII**
  - Current assemblages updated yearly
  - dynamically create assemblage requirements specific to the operation and forces
  - User editable casualty rates and patient conditions
  - Doctrine based demand generation

Logistics P

- **Shows level 5 details of resulting log plan**
- **Supports extensive drill down to individual leg of strategic and theater transportation plans**
  - By organization, equipment/material, & carrier
  - Tabular and graphical routes & utilization data
- **Asset utilization views by carrier type**
- **Generate user defined TPFDD view on demand**
  - By organization, equipment/material, & carrier
  - Flexible data aggregation capabilities

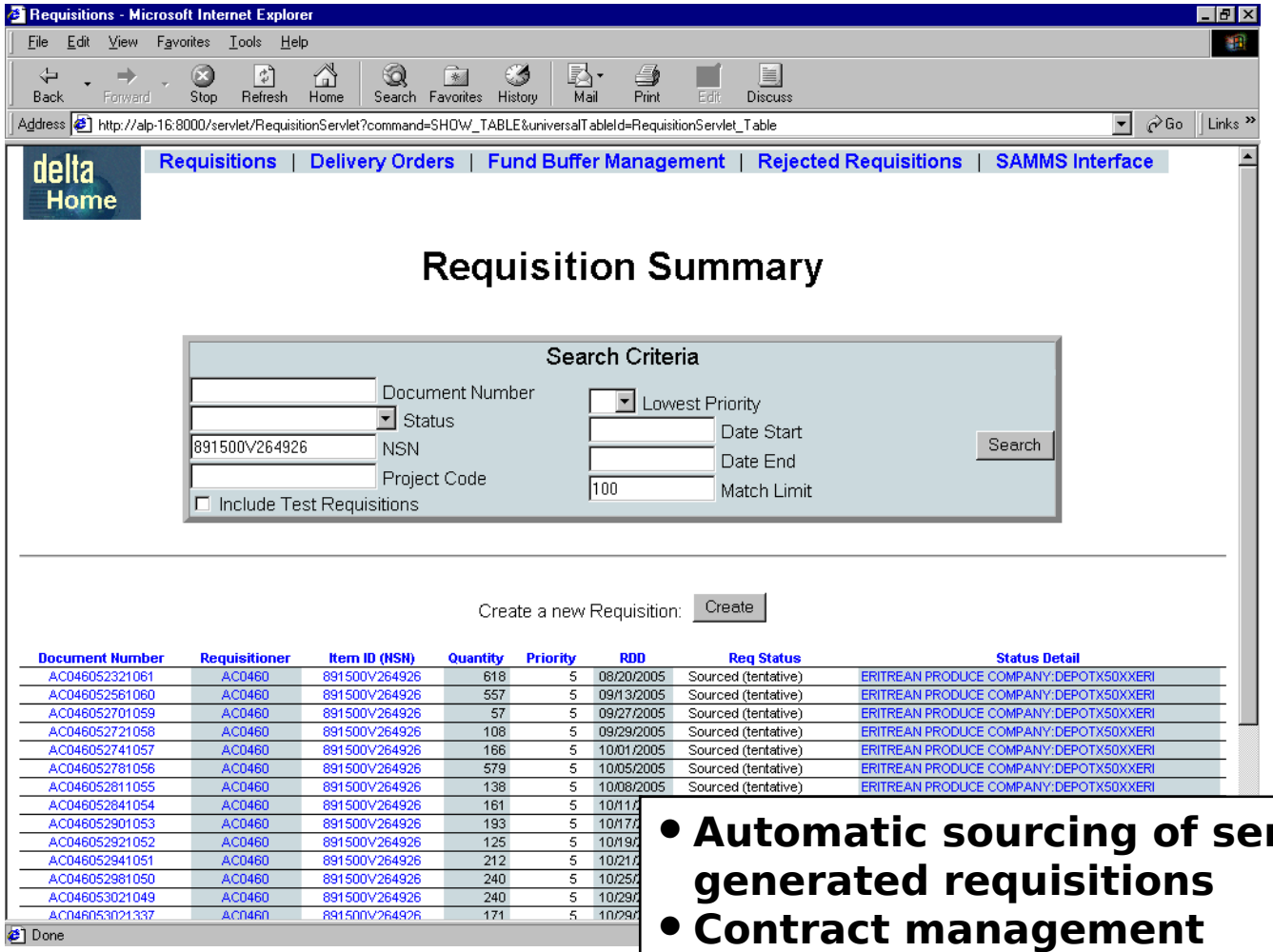


Mapping Component



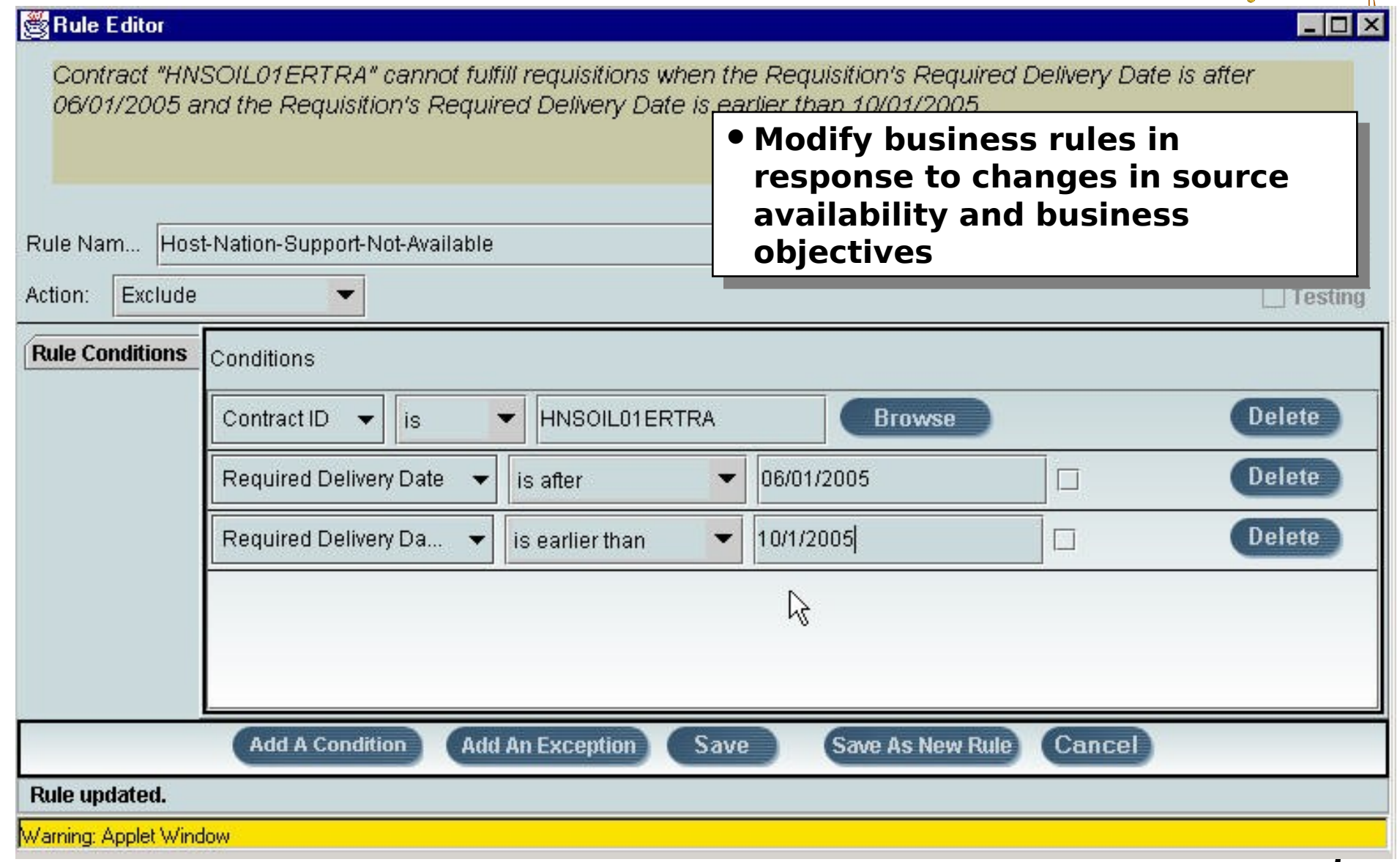
- **Provides visual representation of OPlan**
  - **Time phased geographic locations & movements**
  - **Spatial relationships of combat and support forces**
  - **Supports 2525B specifications**
  - **Variety of data overlays**
  - **User controllable time reference for exploration of the temporal-spatial components**

DELTA Requisitions Interface



- **Automatic sourcing of service generated requisitions**
- **Contract management**
- **Business process management**
- **Contemporary systems interfaces**

DELTA Rule Engine



- **Modify business rules in response to changes in source availability and business objectives**

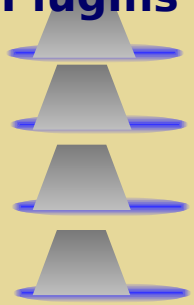
ALP Products

Cougar

Generic Agent

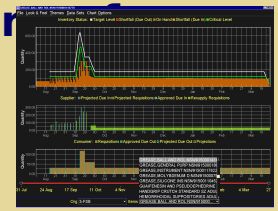
Architecture Document
PlugIn Developer Guide

Generic PlugIns



Scheduler
Assessor
Inventory Management
Skills based Personnel Management
Demand Generation
Sourcing

Generic User Interfaces



Inventory Viewer
Map Viewer
Organizational Viewer
Assessment Viewer

Micro Edition

Sensor Web Robotics
Actuators Sensors

Tools

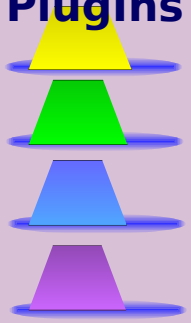
Three Tier UI Framework
Scalability Tester
Configuration Management
Dynamic Configuration
Contracts Base Management
CSMART

Training

Basic Course
Advanced Course

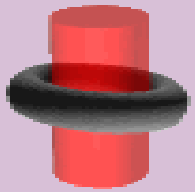
ALP Prototype

Military Specific PlugIns



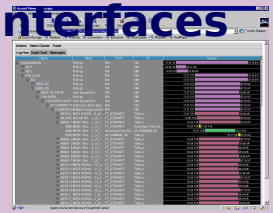
Scheduler (sea, air, overland, rail, ISB Transshipment)
Skills based Personnel Management (Army DS/GS Maintenance)
Demand Generation (I,III,V,VII,VIII,IX)
Sourcing (I,III,V,VII,VIII,IX)

Wrappers & Interfaces



TCAIMS II, GTN, JTAV
SAMMS, POPS, MOMS
World Wide Port System
ULLS
etc. …

Military User Interfaces



TPFDD Viewer
Medical Demand Views
DELTA Viewer
Subsistence

Overall Accomplishments

- **World's most advanced agent architecture**
- **Fastest ever construction of a level-5 logistics plan (~hour [agents] vs. weeks [humans])**
- **A mature distributed information systems technology for realization of the next-generation global logistics enterprise**

We Have Demonstrated the Power of Agent Technologies for Global Operations and Logistics

Logistics Superiority

Advanced Logistics Project (FY96—FY01)

- **End-to-End Control of the Logistics Pipeline**
  - **Fastest ever construction of a level-5 logistics plan (~hour [agents] vs. weeks [humans])**
  - **World's most advanced agent architecture**

UltraLog Program (FY01—FY04)

- **Hardened and Survivable Logistics**
  - **Robust, Secure, and Scalable logistics agents**
  - **Hardened to withstand simultaneous cyber and kinetic attack**

The Context of UltraLog
Survivable Systems Research

- **Core challenges**
  - *Environmental Dynamism:* Security will fail, machines will fail or be destroyed, bugs will happen, the environment will change at high velocity
  - *Multiple Simultaneous Threats:* Information warriors will target our software; kinetic warriors will target our hardware
  - *System Complexity:* Coalition operations, deep supply chains, and other modern teaming and trust arrangements create massive interdependencies
    - Systems-of-systems lack the unified architecture and controls typical of traditional fault-tolerant systems approaches

- **Security barriers alone will not result in a survivable system**
- **Logistics is the right domain**
  - High Payoff: Today's logistics systems are stove-piped, vulnerable, wasteful and cannot achieve DoD transformation objectives
  - Correct Structure: Involves all the above issues of survivability
  - Previous Work: Leverage the results of the Advanced Logistics Project

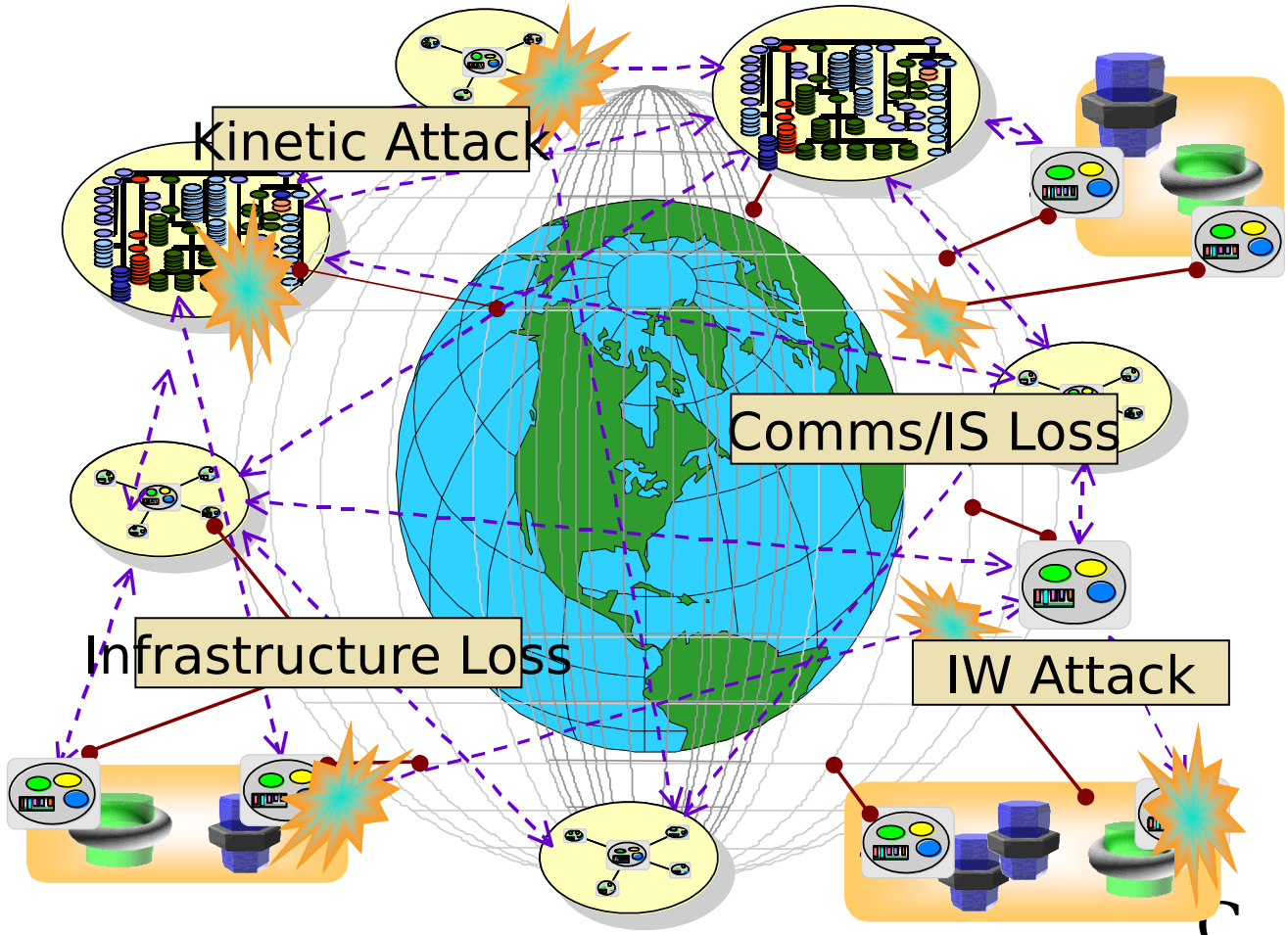
Survivable Operations

The Advanced Logistics Project got control of the global logistics pipeline for moderately stable environments using commercial grade security (PKI, VPN, etc…)

However, the Cougaar technology has not been hardened to be survivable in the chaos of war.

1) How do you make distributed agent systems survivable?

2) How can Agent technology enable fundamental



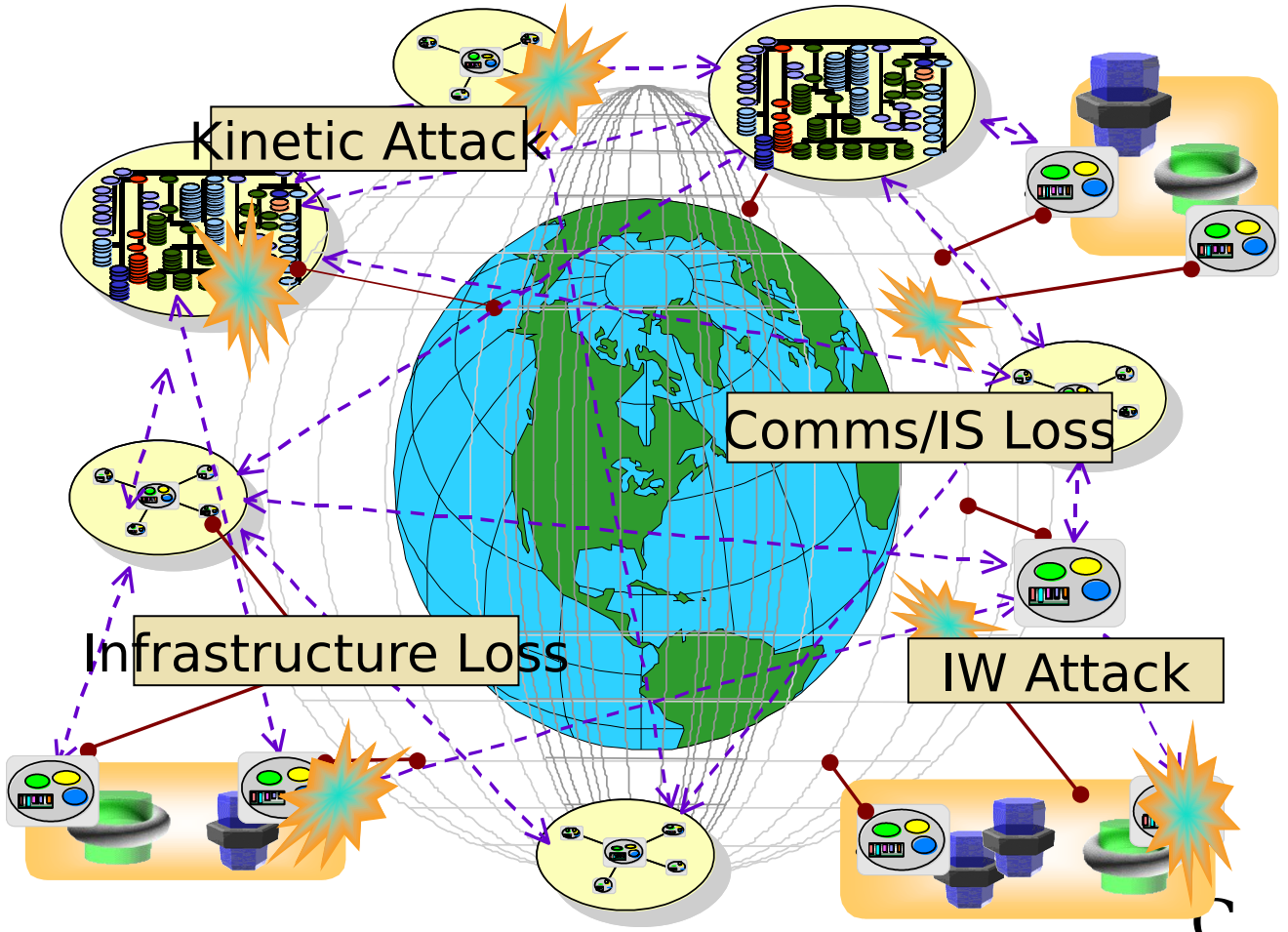
Survivable Operations

Major Region Contingency
180 Days of Global Operations
> 1000 Organization Society

Highly Chaotic Environment
Up to 45% infrastructure loss
Directed Enemy IW Attack

Survivable Operations
< 20% Capability Loss
< 30% Performance Hit

STRETCH GOAL: The world's most survivable information infrastructure

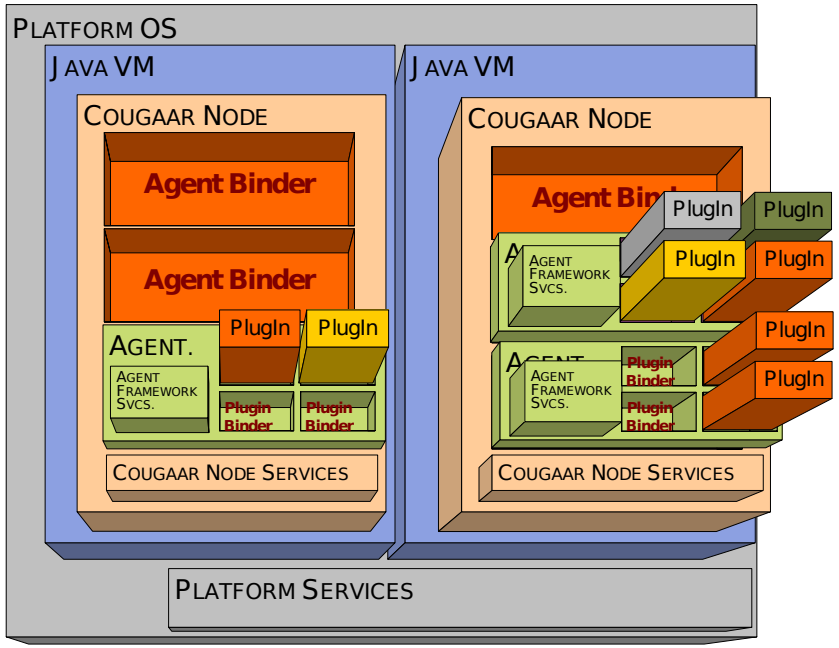


The UltraLog Program

- **A survivable logistics information system**
  - Show continuity of operations while under extreme stress
  - Build on a sophisticated agent workflow framework
- **A strategy for technical success**
  - Treat survivability as an emergent property
  - Develop a distributed agent-based interoperable system of systems, providing:
    - *Security* – Protect confidentiality and integrity of data and resources
    - *Robustness* – Resist, contain, and recover from damage
    - *Scalability* – Stable under rapid changes in size of tasks and resources
  - Assume that best practices of operating systems and network security frequently fail
  - Balance security, scalability and robustness in a continuous tradeoff
- **Two pronged transition approach**
  - Applications to DoD (DLA, GCSS…)
  - Commercial adoption via open source model

Overall UltraLog Strategy

- **Use Cougaar as a Survivability Laboratory**
  - Agent-based design offers new survivability techniques for large distributed systems
  - Inherit logistics domain functionality from the Advanced Logistics Project
- **Implement Mechanisms for Cougaar Security, Scalability, and Robustness**
  - Assume some attacks will get through. Our success at adapting and recovering will define the survivability of our system
  - Control UltraLog society behavior by balancing logistics functionality and system survivability
  - Adapt society task flows to the resources available and the current threat condition
- **Assert and Support a Survivability Claim**
  - Use empirical and analytic means to assess the validity of our survivability claim
  - Develop appropriate metrics and test methods
  - Manage program based on the results of periodic assessments and red team experimentation



Cognitive Agent Architectur (Cougaar) Platform

UltraLog Survivability Claim

UltraLog will act to maximally preserve society function under stress, in accordance with policy

- ***Function*** **is defined by requirements**
  - Measures of Effectiveness, Operational Issues, Measures of Performance, Data Requirements, and the MAU score
  - UltraLog has both Logistics MOPs and Security MOPs
- ***Stress*** **is defined by the UltraLog program goals and threat environment**
  - Define Security, Scalability, Robustness stresses
  - Apply stresses singly, per-class, and jointly, in accordance with the experimentation plan
- ***Policy*** **supplies a set of tradeoff constraints**
  - Security policies provide minimum levels of integrity and confidentiality
  - Functional policies constrain the logistics solution
- ***Act to maximally preserve*** **means the the generation, optimization, and application of UltraLog control strategies**
  - Define sensors, actuators, state estimators
  - Construct system control laws and strategies

Major Region Contingency
180 Days of Global Operations
> 1000 Organization Society

Highly Chaotic Environment
Up to 45% infrastructure loss
Directed Enemy IW Attack

Survivable Operations
< 20% Capability Loss
< 30% Performance Hit

UltraLog Technology

Hardening Cougaar

	ALP	With UltraLog
Robustness	**Basic Fault Tolerance** ➢ Localized persistence of state ➢ Stable under intermittent comms ➢ Run-time manual reconfiguring	**Advanced Battlefield Grade Tolerance** ➢ Dynamic comms-aware redundancy ➢ Catastrophic fault isolation / recovery ➢ Dynamic adaptation to environment ***Highly Survivable***
Scalability	**Peacetime Logistics Scalability** ➢ Time-phased locality of information ➢ Efficient simple negotiations ➢ Rich encapsulation of functionality	**Wartime Logistics Scalability** ➢ Streamlined / compressed negotiation ➢ Variable fidelity adaptive processes ➢ Resource pooling / Mode mgmt ***Guaranteed Stable***
Security	**Standard Commercial Grade Security** ➢ Optimized task grammar / data model ➢ Signed JARS, applets, config files ➢ PKI, inter-community VPNs	**State-of-the-Art Security** ➢ Stochastic traffic masking ➢ Certificate management & RBAC ➢ Adaptive comms routing & encryption ***Resistant to IW Attack***
Project Objective	**Large-Scale Distributed Agent Architecture for Logistics**	**Integrated System Solution for Agent Societies Operating in Intense IW & KW Environment**

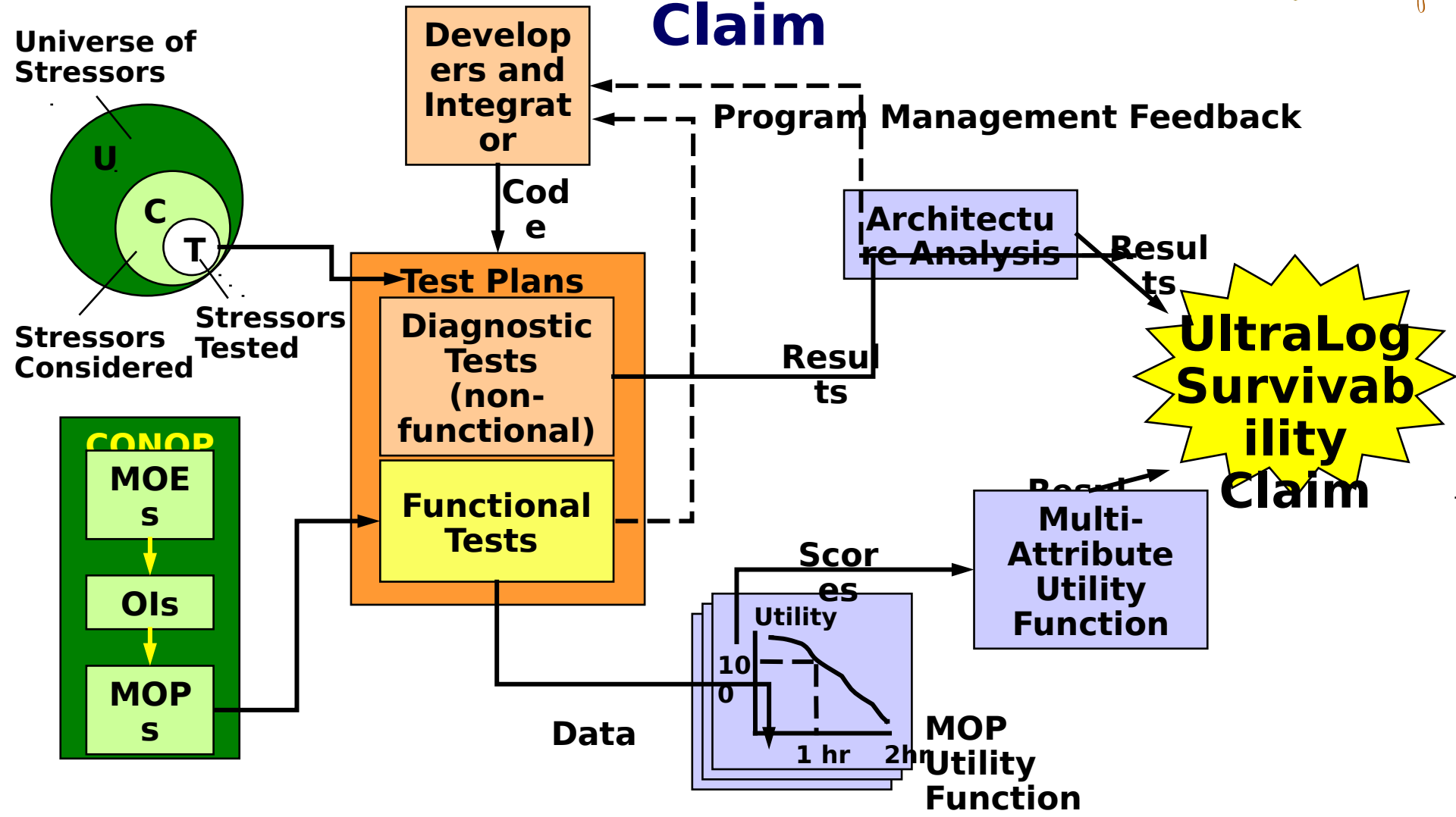
UltraLog Architectural Approach

Cover Every Weakness with Two Strengths

Stress Type	*Avoid*	*Detect*	*Contain*	*Recover*	*Defenses*
					A - Signed Jar Files Class Loader
Security Stresses [Info Attacks]					B- Alert Generation
Insertion of rogue software classes into society	A	A, B		E	C- Leases on Certs/Identity
Insertion of rogue agent into society	D	D, B		C	D- Certificate Authenticated Messaging
Corruption of data between Cougaar and DBs or External Systems	H				E- Rehydration from Persistence
Corruption of data between Cougaar and Users	G				F- Satan-like vulnerability daemon
Corruption of Persisted State	K	K		L	G- SSL UI connections
Attempt to read or modify Agent-Internal data by unauth entitites	J, S, T	J, I			H- Secure JDBC connections
Attempt to read or modify Inter-Agent Messages by unauth entities	M				I- Rovers
Attempt to read Persistent State by unauthorized entities	K				K- Checksummed, encrypted, distributed persistence
					L- Redundant stores and M-of-N techniques
Scalability Stresses [Wartime Loads]					M- Encrypted Messaging
Scaling by #of high-level (root) tasks		R, O	N, P, Y	Q	N- Variable Quality Processing
Scaling By Frequency and Magnitude of Perturbations		"	"	"	O- Chaos Detectors
Scaling By Frequency and Magnitude of Queries		"	"	"	P- Chaos Dampeners
Scaling By #of Organizations		"	"	"	Q- Load Balancing
Scaling By complexity of inter-agent relationships		"	"	"	R- Performance Monitoring
Scaling By #of Nodes		"	"	"	S- Noise Generation
Scaling By #of Agents		"	"	"	U- Hot Spares
Scaling By Bandwidth [In LAN, between LANs]		"	"	"	V- Asynchronous Operations
Scaling By Memory		"	"	"	W- Proxies
Scaling By CPU		"	"	"	X- Health Checking
					Y- Prioritized Operations
Robustness Stresses [Infrastructure Damage]					Z- Alternative Message Transports
Loss of Nodes		X		E	
Loss of Agents		X		E	
Loss of Connectivity		V	W	V, Z	
Loss of Persistence Data		K		L	

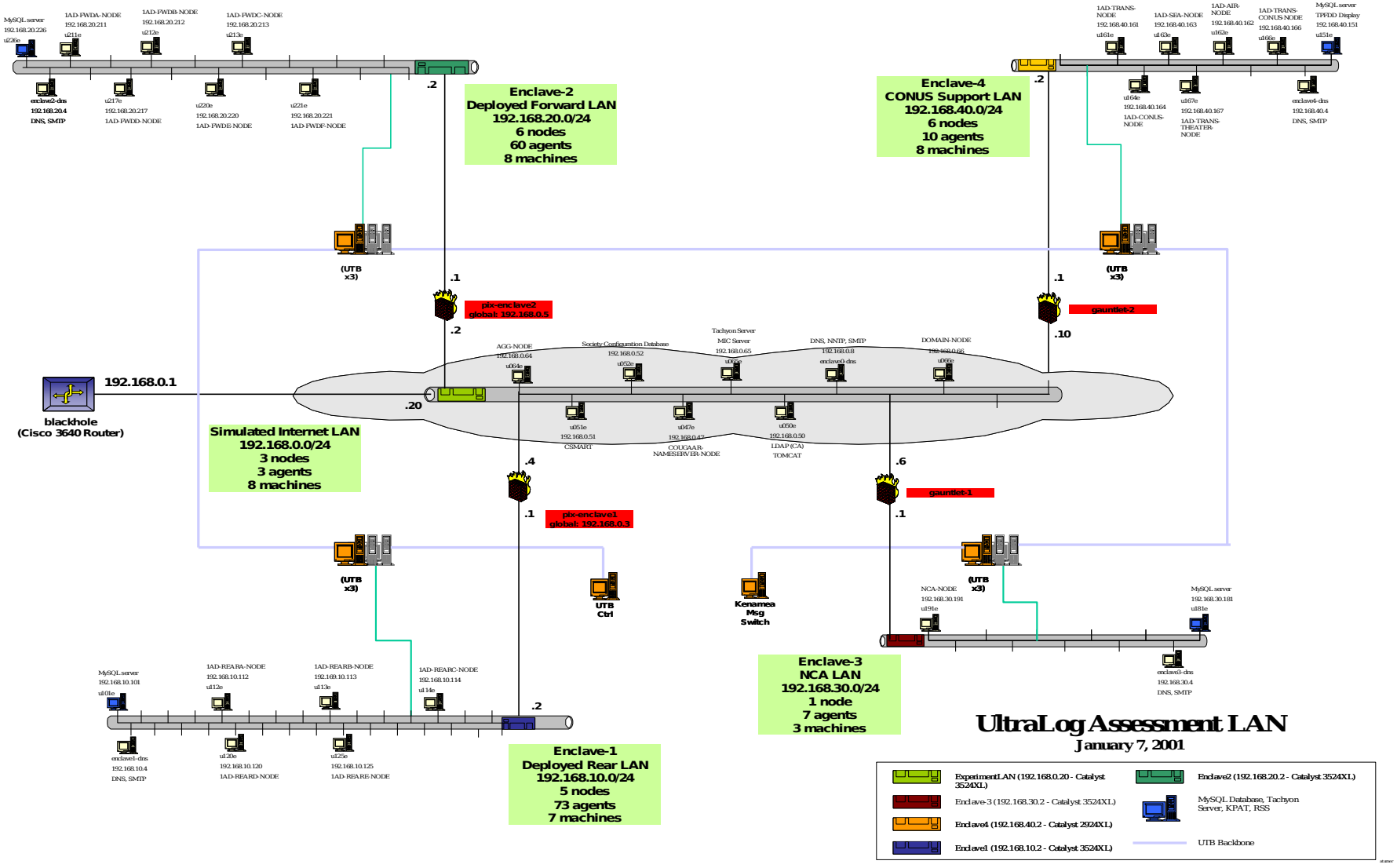
UltraLog Assessment Cycle

Supporting the Survivability Claim



Assessing UltraLog

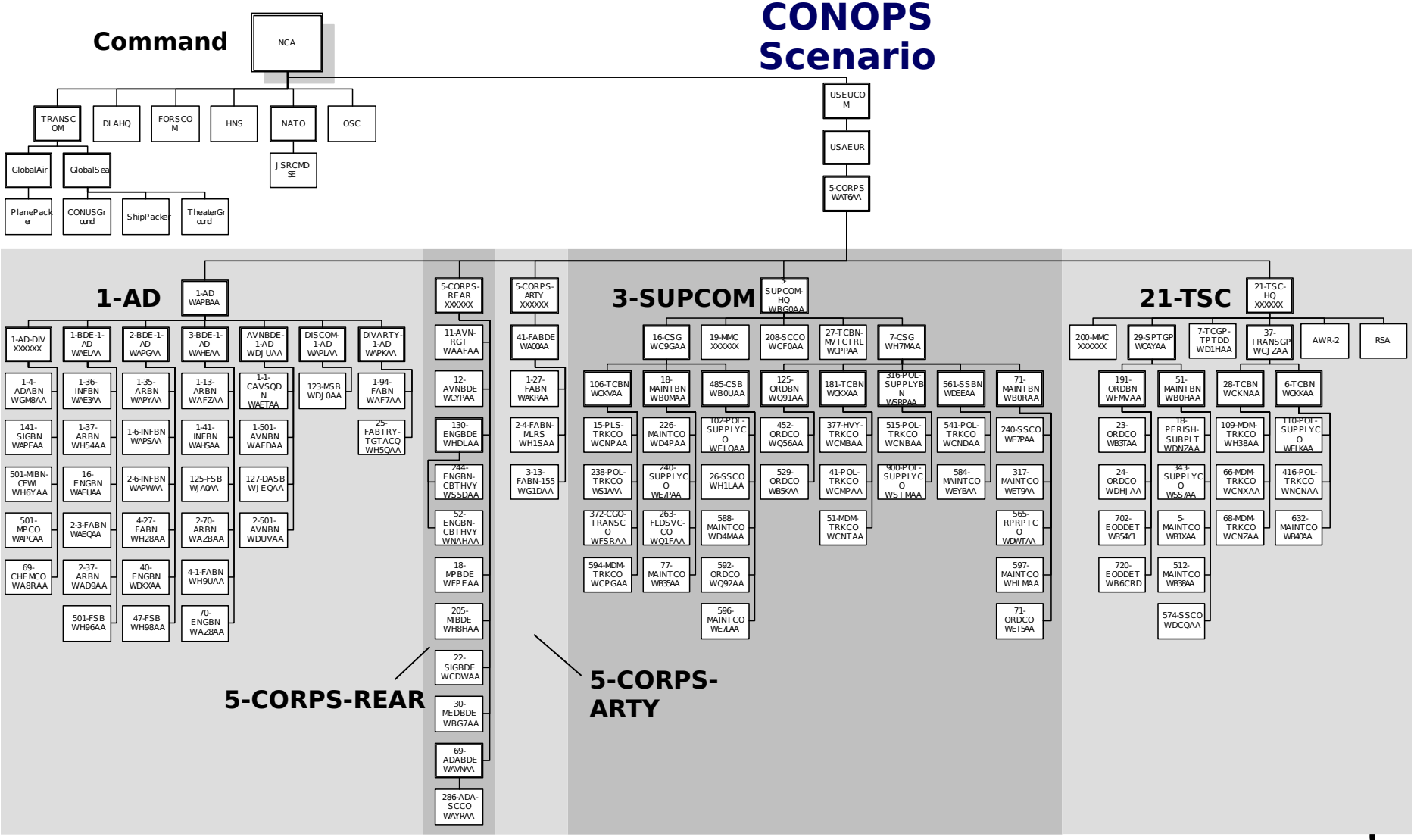
Integration and Testing at the TIC



Initial Assessment Society

Small 1-AD Society (139 Organizations)

Driven by CONOPS Scenario



UltraLog Transition Plan

Department of Defense

Defense Logistics Agency

Future Combat System

Global Combat Support System

Focused Logistics Wargame

UltraLog & Cougaar

Open

www.cougaar.org

Open Source License Commercial transitions

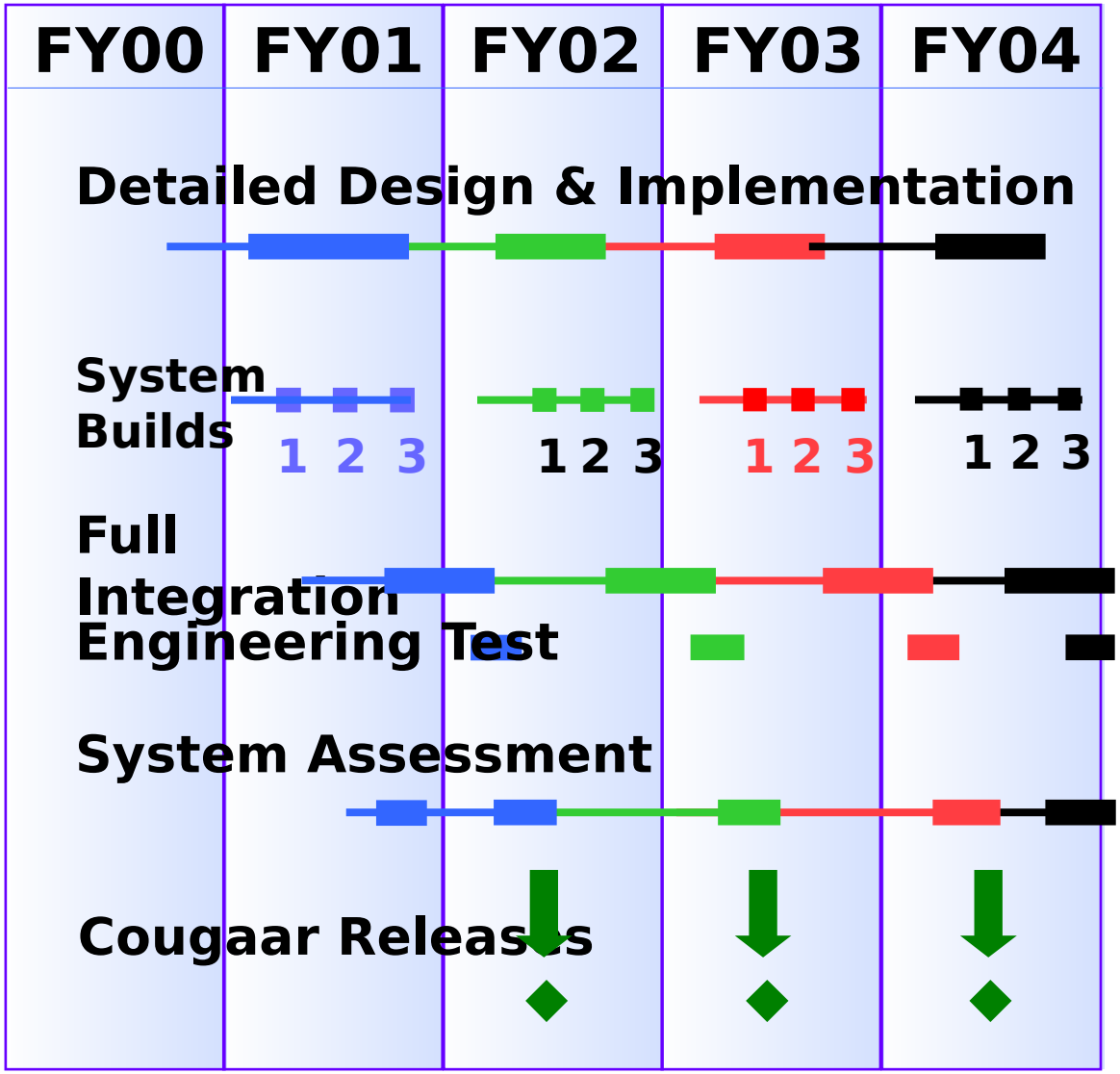
UltraLog Program Schedule

Developer Team
TNAI, BBN, Boeing, GE, SRA, LMI, IET, MIC, OBJS, PSU, MIC, 21st Century, Zel, IHMC, UMemphis, Honeywell

Integration Team
TBBN, Lockheed-Martin, TASC

Assessment Team
SBI, LATA, Sandia, LMI

CCB Transition



UltraLog's End Products

- Revolutionary software for agent system survivability, including:
  - Explicit dynamic balancing of survivability mechanisms
  - Defensive posturing and fault tolerance for maximum robustness
  - Variable fidelity adaptive processes
  - The survivability argument
- Hardened Cougaar
  - Transitions using DARPA's Cougaar Open Source base
  - New Cougaar applications for highly demanding conditions

General Architecture and Specific Algorithms For Survivable Agent Systems

Cougaar Applications for Chaotic

UltraLog technology will demonstrate that agent technology is ***dependable*** in the harshest and most chaotic wartime environments.

Getting UltraLog

www.cougaar.org

Developer's of ANY company, on ANY project, can pick up and apply this technology

- **Available to your existing contractor base**
- **U*L survivability technology injected as it becomes available**
- **Mature enough to be applied now**
- **Free license**

Conclusion

- **The Advanced Logistics Project…**
  - **Developed a complete information technology suite to achieve the vision of Focused Global Logistics**
  - **Demonstrated a prototype end-to-end logistics system**
    - Generated a level 5 TPFDD in an hour
    - Planned and monitored execution of multiple simultaneous operations
    - Dynamically replanned as problems and changes occurred
  - **Matured the Cougaar open-source technology through pilots, experiments and operational fielding with our program partners**
- **UltraLog will…**
  - **Harden the Cougaar technology to be survivable in the most extreme warfare conditions**
  - **Use Cougaar as a testbed to develop state-of-the-art security, robustness, and scalability technologies for agent architectures**
  - **Demonstrate survivable, tailorable logistics under simultaneous cyber and kinetic attack**
  - **Continue Cougaar support and training through ‘04**